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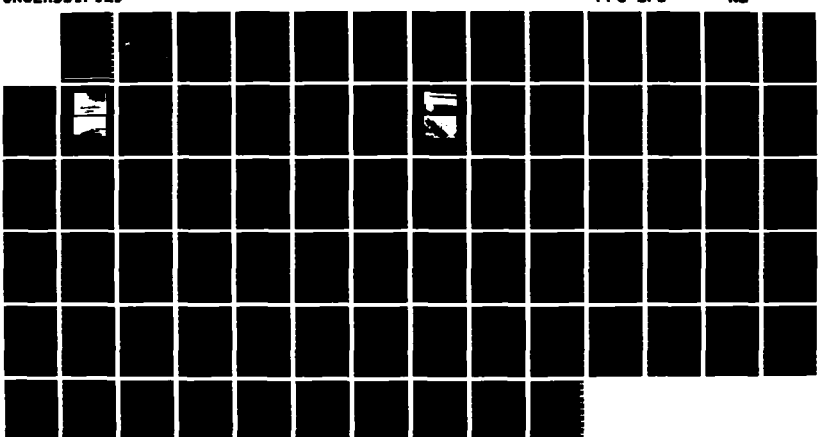

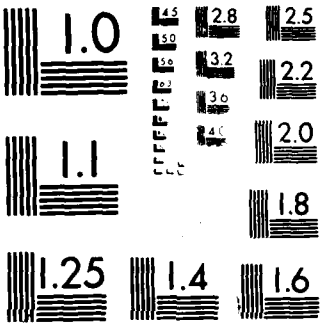

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EXTERIOR ELECTROMAGNETIC RESPONSE OF NASA F-106 AIRCRAFT

V. V. Liepa
S. T. Pennock

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June 1986

Final Report

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AIR FORCE WEAPONS LABORATORY
Air Force Systems Command
Kirtland Air Force Base, NM 87117-6008

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Frequency domain surface current and charge data are presented for the NASA F-106B aircraft when illuminated with a plane electromagnetic wave. Measurements were made on a 1:48 scale F-106A model that had been modified to represent the NASA F-106B. The measurement locations and the field quantities measured correspond to those on the NASA aircraft. Nine different excitations were used including those corresponding to the situations in HPD, VPD-II, and VPD-II fly-by tests performed at Kirtland Air Force Base. The amplitude and phase measurements on the models were performed over 100 to 4770 MHz and for the full-scale aircraft this corresponds to 2.1 to 100 MHz coverage.

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I. INTRODUCTION

The data presented here were obtained to support the lightning measurement program in which the NASA F-106B aircraft is used for collection of direct strike and near miss lightning data (Ref. 1). These data are recorded as output from current and charge sensors mounted on the aircraft and, since the spectrum of the lightning falls well within the range of the aircraft natural resonances, the recorded data may be appreciably affected by these resonances.

The measurements presented here provide the exterior electromagnetic response of the aircraft when illuminated by a plane wave. These are frequency domain data for the surface current and charge (amplitude and phase) normalized to the incident field and, as such, can be referred to as transfer functions for the exterior coupling. A cursory look at the data immediately provides the aircraft resonant frequencies and the enhancement of the surface field at the resonances. Transformation of the data to time domain will provide the impulse response which, when convoluted with an appropriate driving waveform, would give the time domain field on the aircraft.

Some of these data have already been used to determine expected signal amplitudes and accordingly preset the recorder gain settings for the full-scale ground and fly-by tests performed at Kirtland Air Force Base*. A too-high (gain) setting of the digitizers can result in saturation of the signal, or a low setting can result in a low dynamic range or a noisy signal. Other applications of these data include the comparison of scale model data (frequency domain) with the data obtained in full-scale simulator (time domain) tests and, eventually, as a data base for correction of the measured lightning data by NASA F-106B.

---

1. Baum, C. E., E. L. Breen, F. L. Pitts, G. D. Sower and M. E. Thomas, "The measurement of lightning environmental parameters related to interaction with electronic systems, IEE Trans., Electromagnetic Compatibility, Vol. 24, pp.123-137, 1982.

* Lee, K.S.H., Dikewood, personal communication, March 1984.

The data presented herein were measured for the same locations and field components for which the NASA F-106B has been instrumented. The measurements of charge and current are presented for eight locations or stations on the model under up to nine excitation conditions which include

- top incidence, E-parallel to the fuselage
- top incidence, E-perpendicular to the fuselage
- side incidence, E-vertical, etc

These excitations were selected to simulate the HPD, VPD-II and VPD-II fly-by test situations as well as lightning measurement situations such as bottom incidence (Ref. 2).

The data are presented in the form of amplitude and phase plots as a function of the full-scale frequency. In total there are 48 transfer functions presented. The data have also been stored on magnetic tape for future availability.

---

2. Riffe, L. G., Detailed Test Requirements in Comparison of Natural Direct Strike Lightning and Simulated NEMP on NASA F-106, TRW Report No. 42156-6011-UT-00, Albuquerque, N.M., December 1983 (DRAFT).

II. FACILITY

The measurements were made in the University of Michigan Radiation Laboratory's surface (and near) field facility (Ref. 3), a block diagram of which is shown in Figure 1. The system is a CW one in which the frequency is swept (stepped) over a 100 to 4770 MHz range. A key part of the facility is a tapered anechoic chamber approximately 50 ft in length. The rectangular test region is 18 ft wide and 12 ft high. The rear wall is covered with 72-in high-performance pyramidal absorber, with 18-in material used on the side walls, floor and ceiling. The material in the tapered section (or throat) is 2-in hairflex absorber. In a way the chamber can be thought of as a lossy-wall horn antenna terminated by the rear wall. The excitation signal is launched from a single exponentially tapered broadband antenna located at the apex of the chamber. The antenna is fixed and since the radiated signal is horizontally polarized, the pseudoplane wave in the center ('quiet zone') portion of the test region is also horizontally polarized.

The instrumentation is centered around a Hewlett-Packard 8410B network analyzer that has been modified to operate as an HP8409 which phase locks the measurement frequency (r.f.) to the network analyzer local oscillator signal provided by a synthesizer. An HP9830A calculator controls the frequency to be measured, switches in the appropriate power amplifiers and low-pass filters, and reads and stores the amplitude and phase of the signal picked up by the sensor. During a run, the frequencies are stepped from 100 to 4770 MHz in 500 steps. Because of the limited memory size of the calculator, the data are recorded in four bands: 100 to 410 MHz (in 2.5 MHz steps), 415 to 1035 MHz (in 5.0 MHz steps), 1030 to 2280 MHz (in 10.0 MHz steps), and 2290 to 4770 MHz (in 20.0 MHz steps). The data from each band are stored by the HP9830A calculator on standard audio cassettes and later are transferred to an HP9845B calculator for processing and plotting the data. If substantial processing or computation is involved, or if a need exists to write the data on standard computer tape, or to make it available on file to other users via computer nets, the data are transmitted to the central University of Michigan AMDAHL (IBM compatible) computer system.

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3. Lee, K.S.H. (ed.), EMP Interaction: Principles, Techniques and Reference Data, AFWL-TR-80-402, pp. 267-276, December 1980.

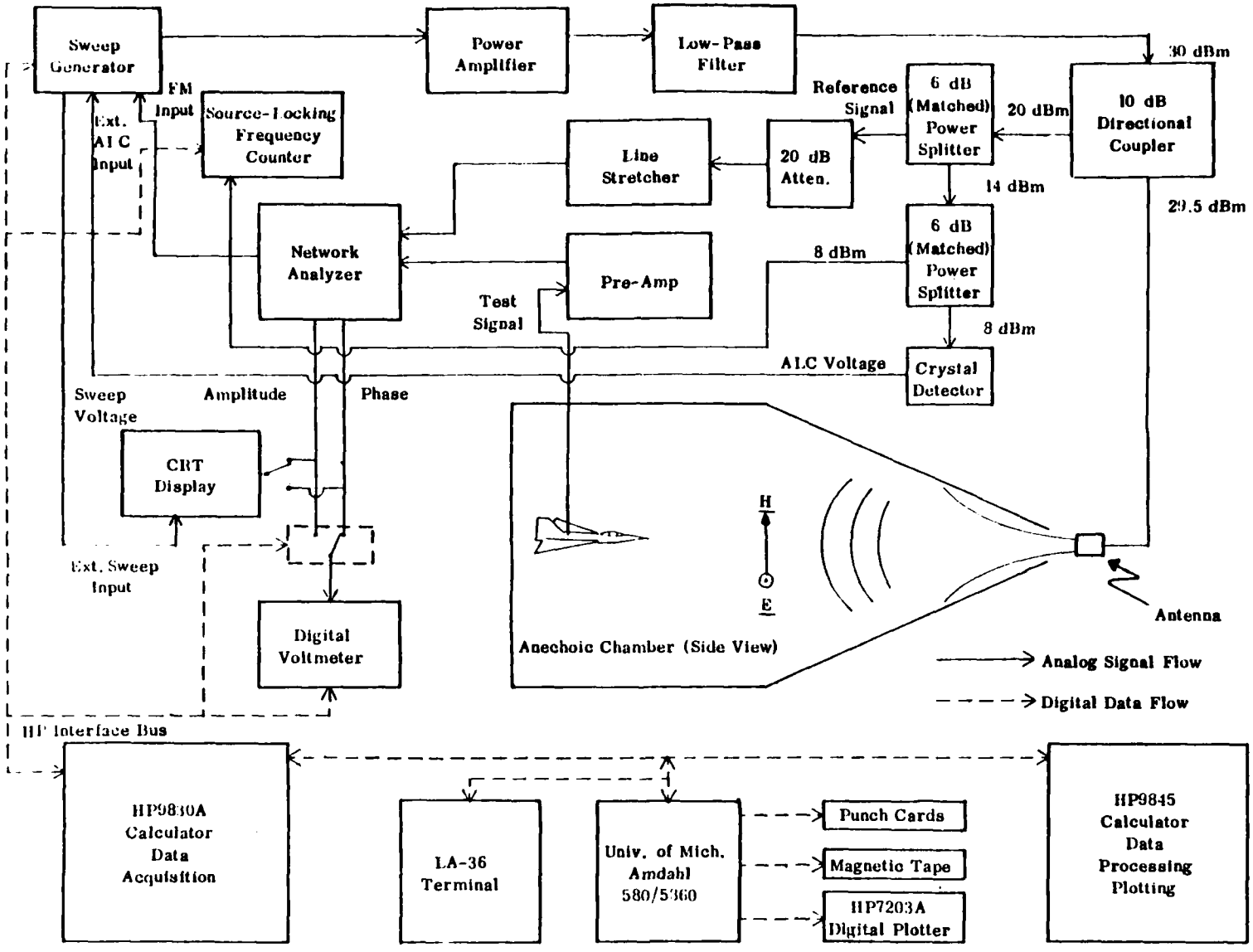

Figure 1. Block diagram of the facility.

The signal that is measured by the network analyzer is a function not only of the surface field but also of the entire facility, including the probe, chamber, antenna, amplifiers and cabling; it would be virtually impossible to separate and to correct for the contribution of each. The approach taken is to apply an appropriate calibration or normalization to the entire system whereby the response of the facility and the instrumentation are, in principle and practice, removed from the test object. In short, a measurement is made on an airplane model (test measurement) and then repeated on a metal sphere of known diameter (calibration); the ratio of the two plus additional correction for the sphere response gives the required data.

III. MODEL

Since F-106B models were not readily available, we used a 1:48 scale F-106A kit (Monogram, No. 5809) and built it into a NASA F-106. The model was constructed in the wheels-up position and without any external stores. The basic difference between the F-106A and NASA F-106B is that the F-106A is a single seater and the NASA F-106B is a two seater. Hence, the canopy for the NASA F-106B is slightly higher and extended toward the back over the copilot's seat. In our model, the original F-106A canopy was used, but by deleting the coating or metallization of the rear portion that normally would be metal, an effect of a larger canopy was simulated. To simulate the metal framing of the canopy, narrow strips of copper tape were used. On the model the joints and other surface imperfections were filled in with automotive body putty, sanded to a smooth finish, and the entire model apart from the radome and canopy were painted with several coats of high grade silver paint (DuPont No. 4817, or equivalent).

The fuselage (from the bulkhead to the top of the vertical stabilizer) and the wingspan were measured and by slight sanding (shortening) of the wingtips the same length-to-wingspan ratio was achieved as for the full scale dimensions. To simulate the NASA boom a 0.8 mm (0.032 inch) diameter brass wire was extended from the bulkhead forward through the tip of the plastic radome. The resultant scale factor for both the fuselage and the wingspan came to 1:47.667 and was used in changing the laboratory frequencies to the full-scale frequencies simply by dividing the laboratory frequency by 47.667.

Figure 2 shows the full scale and the model dimensions needed for scaling. Also shown in the figure are the measurement locations or stations. In Figure 3 are two photographs of the model showing the overall view and the canopy detail.

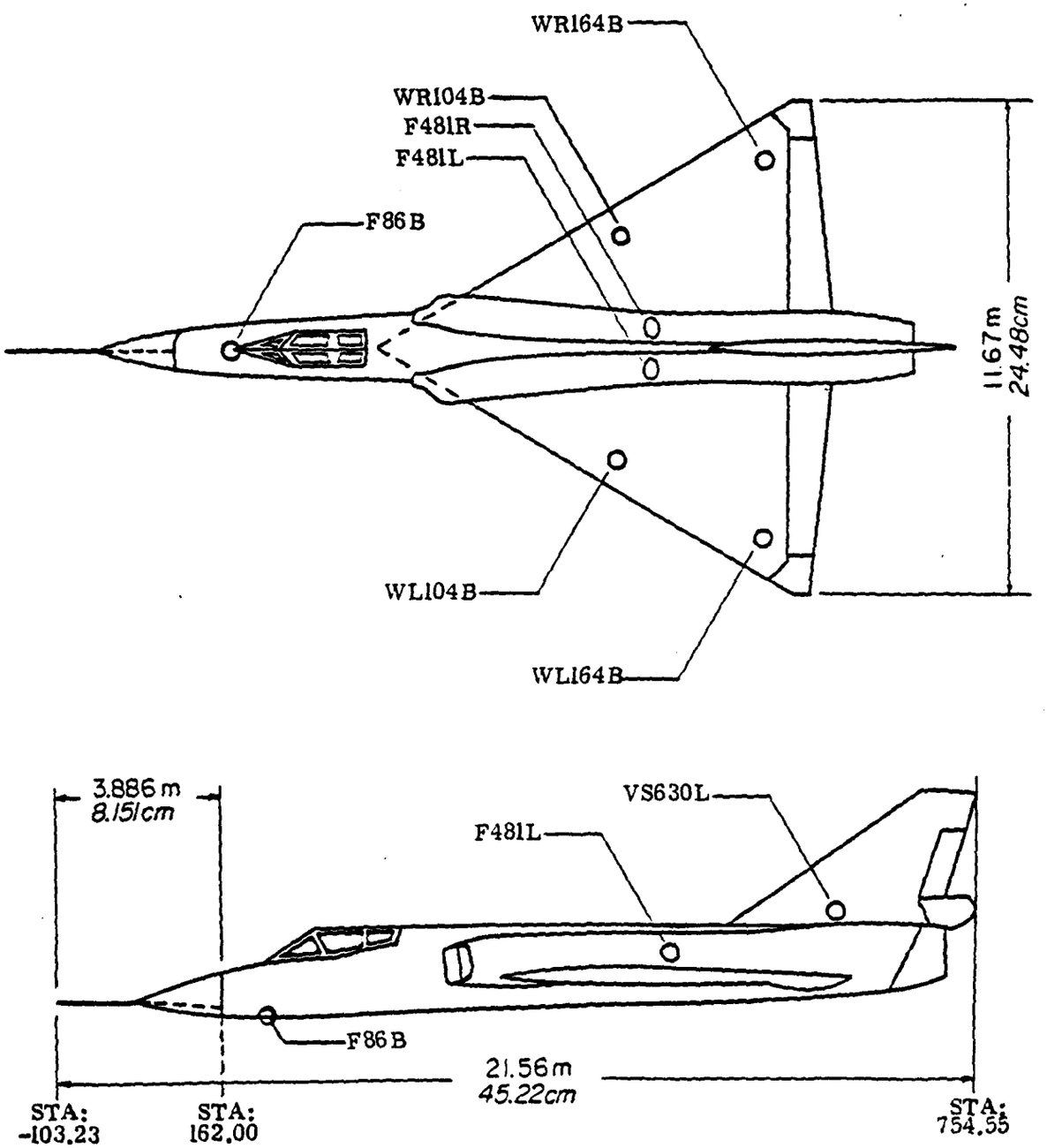

Figure 2. Locations of measurement stations and dimensions of model and full-scale aircraft. (Dimensions in meters: full-scale; dimensions in centimeters: model.)

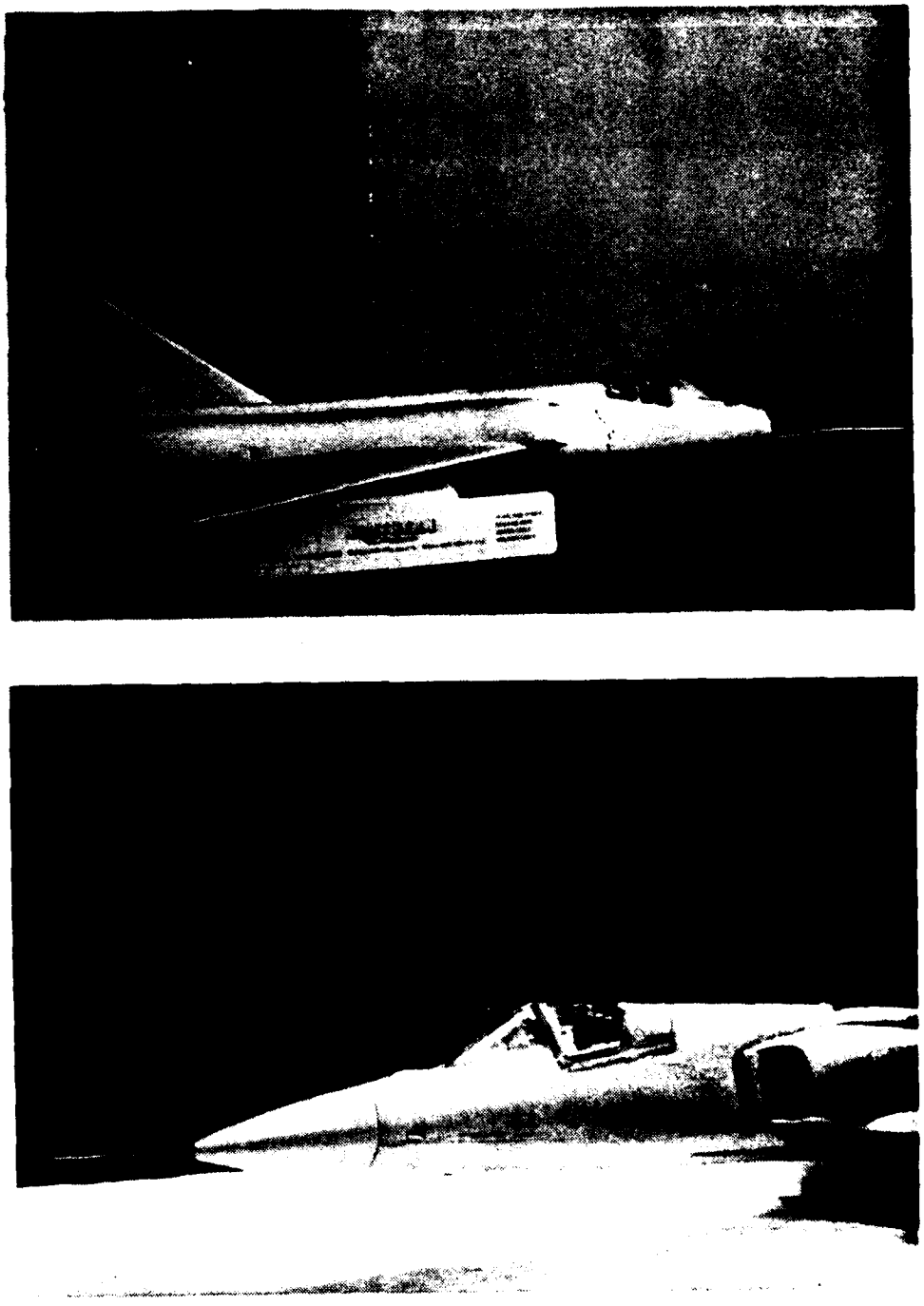

Figure 3. Photographs of the model used. Upper photo: model after assembly and painting with silver paint. Lower photo: plastic radome and canopy.

IV. MEASUREMENTS AND DATA

1. MEASUREMENTS

The procedures used to make the measurements were similar to those of previous programs that have included measurement of surface fields on E-3A, F-16A, B-52, A-7E and, most recently, F-111B aircraft (Ref. 4). In the anechoic chamber, the model was supported on a Styrofoam pedestal, simulating for all practical purposes the free space or in-flight condition. The measurements of the surface currents and charges were made at locations on the model indicated in Figure 2. The locations are further described in Table 1. On the fuselage the locations are identified by station numbers corresponding to inches on the full-scale aircraft measured from an imaginary plane on the radome located 103.23 in from the tip of the boom (Fig. 2). For example, a designation F86B refers to fuselage (F), Bottom (B) 86 in from the imaginary reference. The wing stations are identified by 'W' and the vertical stabilizer by 'VS'. Letters 'L' and 'R' refer to the left (port) or right (starboard) side, respectively.

Figure 4 shows the nine illuminations for which the measurements were made and the convention used to define the directions of the surface field components. The excitations are further described in Table 2. On the fuselage the axial current component, J_a, is defined in the direction of the fuselage axis, and on the wings it is in the directional normal to the fuselage. The circumferential component, J_c, is always perpendicular to J_a, and the normal electric field component (charge) is always defined to be in the outward direction.

Of the eight measurement locations and the nine excitations indicated in Figures 2 and 4, respectively, not all of the possible combinations were measured or presented. Excluded were cases which were of no interest for the full-scale measurements program and cases where the data were bad, for reasons such as broken cable or loose connections. The measurements were made using laboratory-constructed miniature (current) loops and (charge) monopoles as

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4. Liepa, Valdis V., Free Space Model FB-111A Scale Model Measurements, University of Michigan Radiation Laboratory Report No. 017463-5-T; Interaction Application Memo 39, July 1982.

TABLE 1. F-106 MEASUREMENT STATIONS

Station	Sensor Location	Measurement	Sensor Location Boundaries
F86B	Panel on bottom of forward fuselage	Q	On centerline, between STA:77.00 and STA:94.76
F481L	Panel on upper fuselage, port side	JC	Between STA:472.00 and STA:487.80
F481R	Panel on upper fuselage, starboard side	JA	Between STA:472.00 and STA:487.80
VS630L	Panel on port side of vertical stabilizer	Q	Between STA:614.80 and STA:645.28, above WL34.70, through WL49.50
WL104B	Panel on bottom of port wing	JA	Between STA:431.00 and STA:472:00 between BL160.44 and BL107.50
WL164B	Panel on bottom of port wing	Q	Between STA:556.75 and STA:593.46, between BL160.44 and BL167.94
WR104B	Panel on bottom of starboard wing	JA	Between STA:431.00 and STA:472.00 between BL99.94 and BL107.50
WR164B	Panel on bottom of starboard wing	Q	Between STA:445.75 and STA:593.46, between BL160.44 and BL167.94

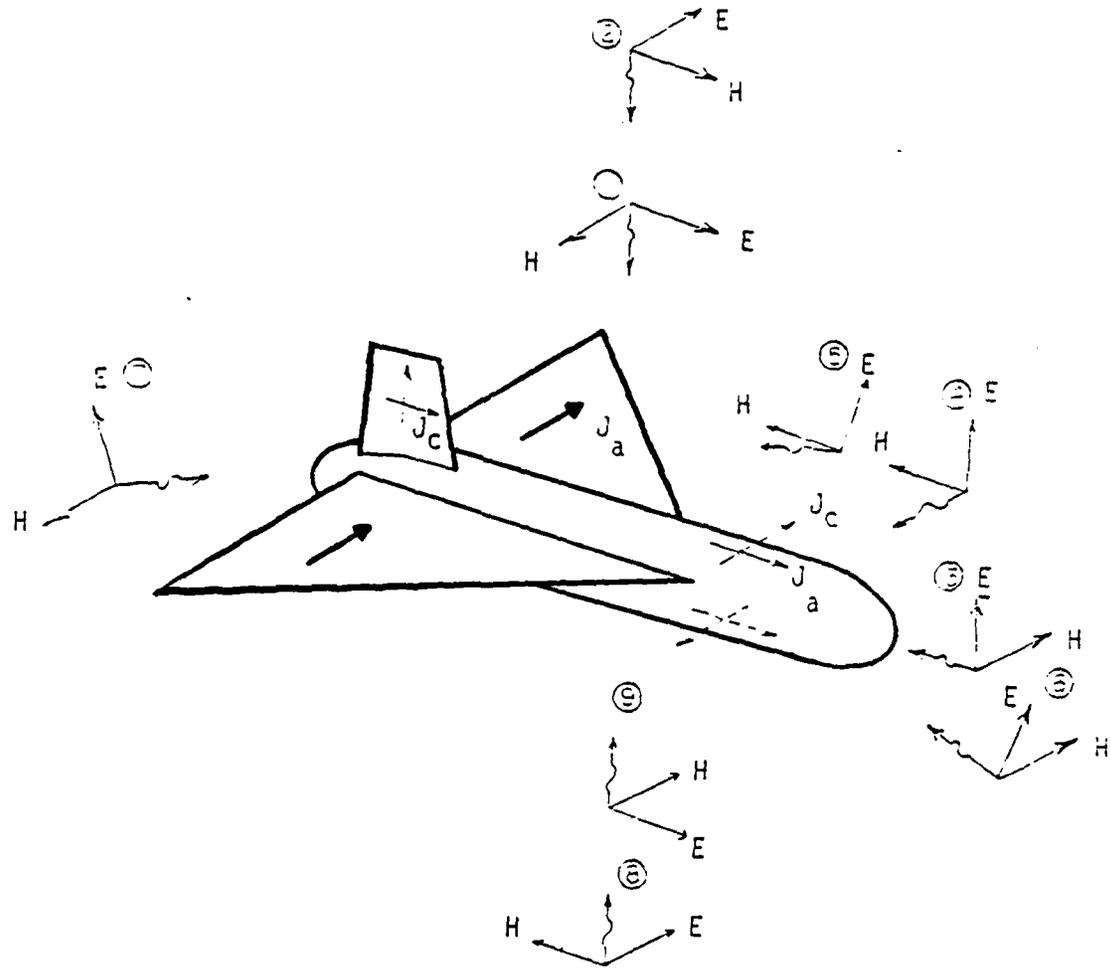


Figure 4. Excitation field and surface current directions on the model.

TABLE 2. EXCITATION DESCRIPTIONS

Number	Description
1	Top incidence, E parallel to fuselage; E direction from tail to nose
2	Top incidence, E perpendicular to fuselage; E direction from right to left wing
3	Nose-on incidence, E vertical
4	Left-side incidence; E vertical
5	Left-side incidence, 30 degrees below; E vertical
6	Nose-on incidence, 30 degrees below; E vertical
7	Tail-on incidence, 30 degrees below; E vertical
8	Bottom incidence, E perpendicular to fuselage; E direction from right to left wing
0	Bottom incidence, E parallel to fuselage; E direction from tail to nose

Also refer to Fig. 2

shown mounted on the model in Figure 5. In the top photo is the current sensor mounted at F481R to measure the axial current J_a. The sensor was constructed using a 0.020-in-dia 50-Ω semirigid coaxial cable and an OSSM-series (Omni-Spectra, Inc.) output connector. It is a half-loop, ground plane sensor, about 3 mm-dia attached to a 10-mm square ground plane. The lower photo shows a charge probe mounted on the far left side of the vertical stabilizer at VS630L to measure the charge. It is also built on a 10-mm square plate and the sensing element is simply a 3-mm extension of the center conductor (with the dielectric) of the coaxial above the plate. The dielectric is left on strictly for rigidity.

Due to the excellent detail of the model it was easy to identify the panels on which the sensors are mounted on the actual aircraft. To mount the probes on the model, a 1/4 in-dia hole is drilled at the center of the appropriate panel, through which the connector and the cable are passed, and the probe is then taped down with conducting adhesive copper tape (No. 1181, 3-M Co.). Only one probe is mounted on the model at a time, and after the measurement the probe is moved to the next location and the previous hole taped over with copper tape.

A typical measurement consists of two parts: the calibration and the test measurement. For the calibration the signal is measured with the same probe on a body whose surface field is known--usually a sphere 3.133 in-dia that can be parted into two hemispheres to allow a surface probe to be mounted. The probe is then removed from the sphere and remounted on the model. The (test) measurement is repeated without any other changes. The ratio of the test data to the sphere data, plus a correction to relate the sphere data to the incident field, gives the field on the body relative to the incident field value, i.e., the transfer function.

How accurately the sphere and the model can be placed in the chamber relative to some reference plane determines the phase accuracy of the measurement. Our goal is to be accurate in placement within 1 mm, but in practice the difference may be 2 or 3 mm, which for full scale translates to 0.15 deg at 1.0 MHz and increasing to 7.5 deg at 50 MHz.

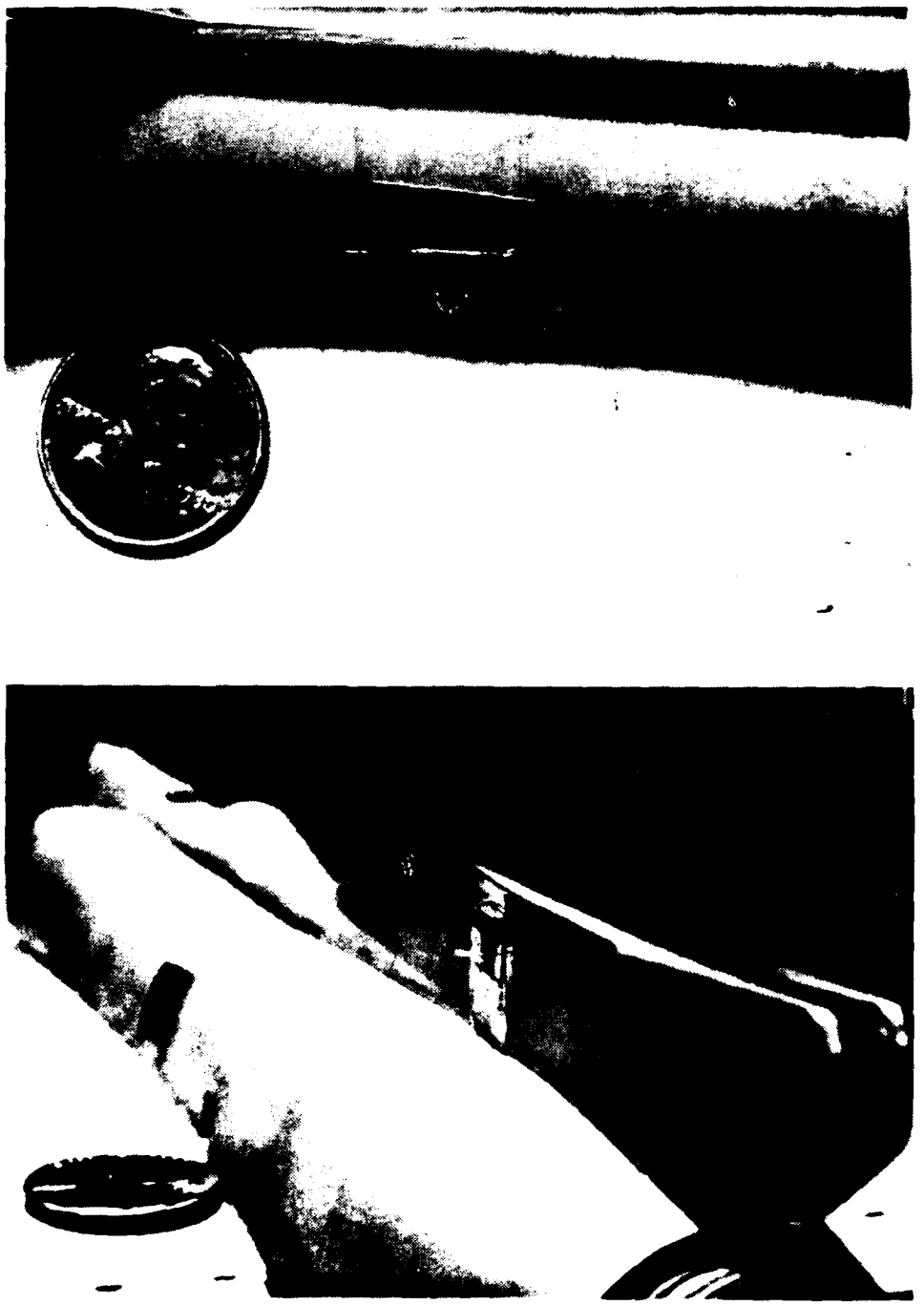


Figure 5. Probes used in measurements. Top photo: current loop mounted on the right side of the fuselage at STA:F481R to measure axial current. Bottom photo: charge probe mounted on the left side of the vertical stabilizer at STA:VS630L.

2. INTERPRETATION OF DATA

For an illustration of the data measured, Figure 6 shows the charge measured on the bottom of the wing for top incidence with the electric field parallel to the fuselage. In the upper right-hand corners of this (and other) plots there is an abbreviated title of form

F-106A, STA:WL164B,1,Q;FT1617

which identifies the particular measurement. The abbreviations are as follows:

F-106A	model used (modified to represent F-106B)
STA:WL164B	measurement station, wing, left, bottom (c.f. Fig. 2)
1	excitation, top incidence, E-parallel to fuselage (c.f. Fig. 4)
Q	field component measured
FT1617	data filename

The raw data from a measurement is usually somewhat noisy near the low end (2 - 20 MHz) and on many measurements takes off above 95 MHz, as shown by the dotted line in Figure 6. This can be attributed to the noisy low level signal in calibration measurements due to low available excitation power. Since such rise at the high frequency end, as well as a similar one at the low frequency end, can be attributed to the measurement noise, ends of the curves are often cut and, consequently, one will find that not all data cover the same frequency range. For example, the highest frequency measured is 4770/47.667 = 100.1 MHz, but when processed it may be 95.6 MHz due to the cutting off the top end of the curve.

To remove the noise or rapid oscillation that appears to be caused by chamber reflection and cable mismatches, the data are processed through the FILTR5 program that gives slight filtering or smoothing based on convolution and convolves sinc(= sin x/x) functions with the frequency data. The program was developed for the FB-111A measurements (Ref. 4) and was then called FILTR2. Minor changes have been added to FILTR5. The convolution of the sinc function with frequency data is equivalent to gating or multiplying the time domain signal by a window function. The filtering that has been applied to the data presented has an equivalent window 300 m long, or about 15 aircraft

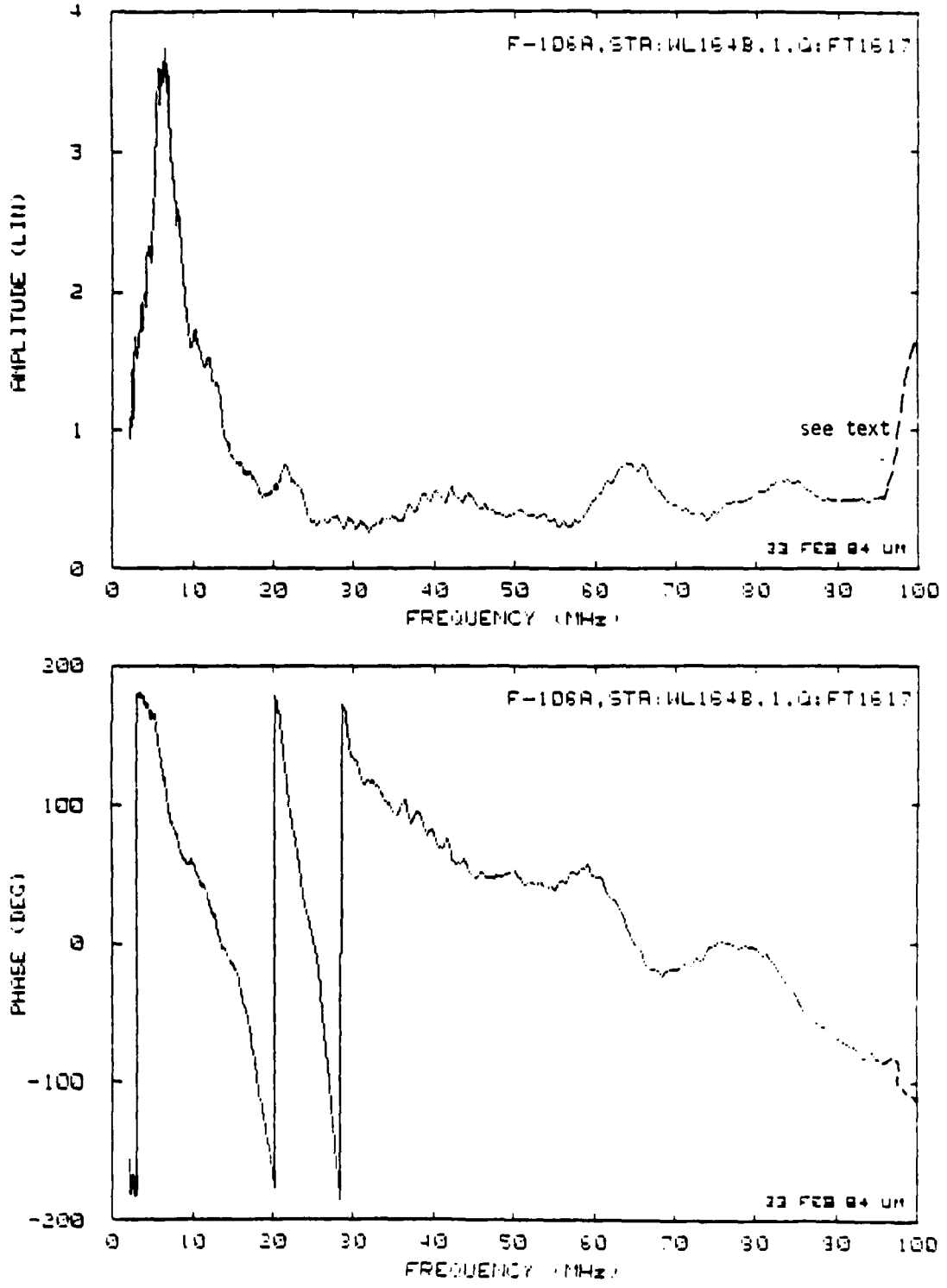


Figure 6. Illustration data (unfiltered).

lengths. As seen in Figure 7, such filtering removes the noise, but still retains even the fine oscillation seen in the 30 to 50 MHz range of the curve. Such oscillations are estimated to be coming from a scatterer some 150 m from the aircraft, or about seven aircraft lengths. In the new measurements such is a distance from the model to the chamber ceiling, for example. Decreasing the window size would remove these oscillations, but at the same time would also lower the resonant peak.

All data presented have been filtered or gated with a 300-m window and in the process the filenames changed from FT to FX prefices.

The data presented are all normalized to the incident field value, i.e., J/H_0 for the surface current and E_n/E_0 for the charge. The phase is referenced to that of the incident field at the location where the measurement is made, based on the $\exp(j\omega t)$ time convention. In Figure 7, for example, E_n/E_0 or charge starts from about unity at 2.0 MHz, rises to a peak value of about 3.6 at 6.3 MHz and then wanders about a value of 0.5 up to 95.0 MHz. The phase starts at -180 deg and keeps on decreasing with frequency, which is consistent with the particular situation since for the top incidence the energy must travel around the wing to get to the bottom at the measurement point, which is a longer path than a direct line used in defining the phase reference.

Table 3 summarizes the cases for which the data are presented in Section 4 and is useful for identifying a particular measurement by a file number such as FX1309 appearing in the upper corner of the first data plot. The filename numbers were assigned in the order in which the measurements were made and, since not all measurements yielded usable data, the numbers are not sequential. There are also some files where multiple measurements were taken and the data averaged. The plots are arranged in increasing numerical order for the files.

The data for both the filtered (FX-files) and unfiltered (FT-files) have also been stored on IBM compatible tape. The file format is:

Line 1 FILENAME (4A4)
2 Comments (18A4)
3 Comments (18A4)
4 TITLE used in plotting (18A4)

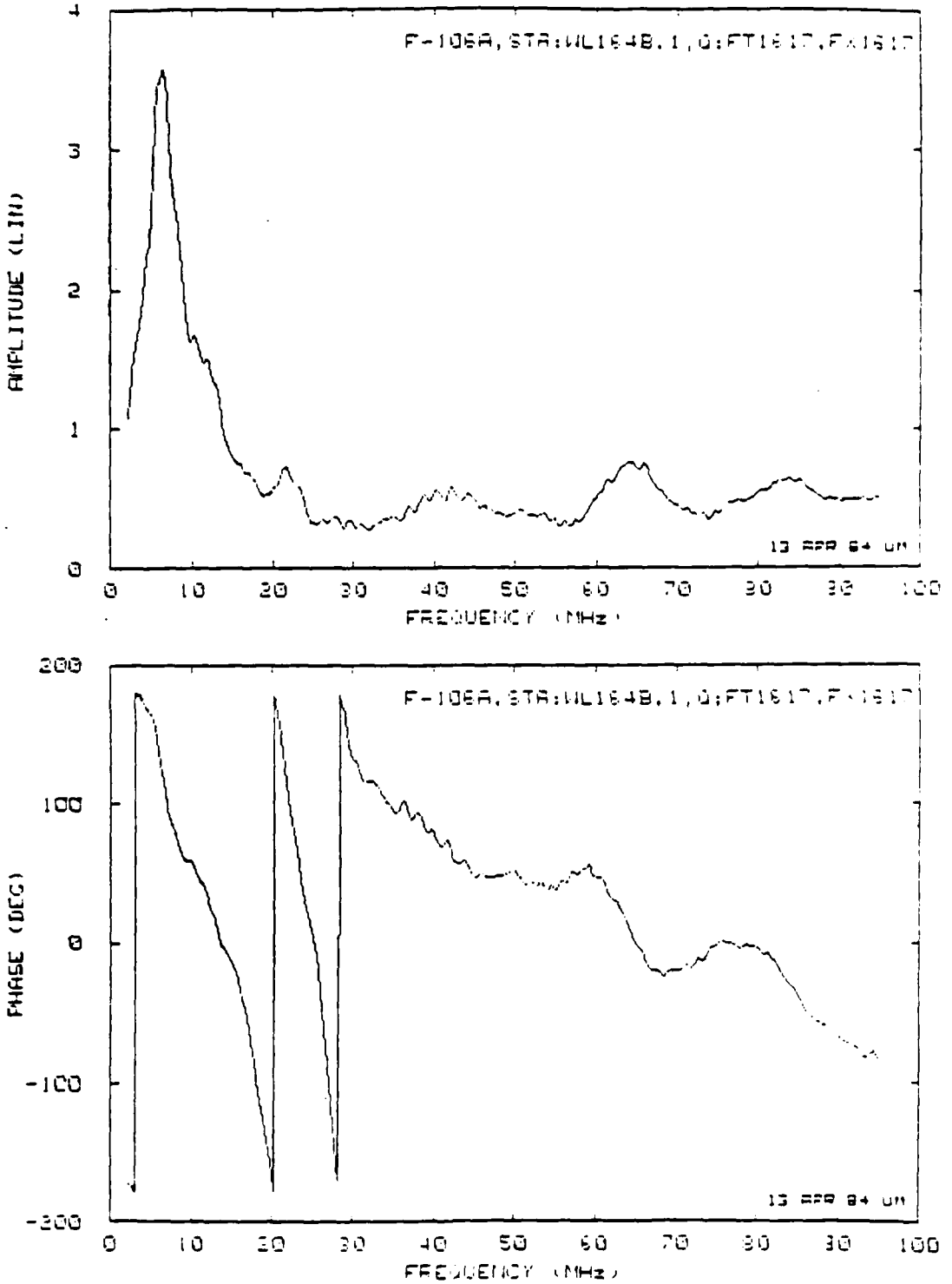


Figure 7. Illustration of data (filtered).

TABLE 3. MEASUREMENT MATRIX

Station \ Orientation	1	2	3	4	5	6	7	8	9
F86B Q	FX1757		FX1773	FX1817	FX1825	FX1765	FX1801		FX1809
F481L JC	FX2325	FX2373	FX2341	FX2401	FX2409	FX2333	FX2349	FX2365	FX2357
F481R JA	FX2433	FX2501	FX2449	FX2509	FX2517	FX2441	FX2457	FX2473	FX2465
VS630L Q		FX1409	FX1465[1]	FX1417	FX1425	FX1433			
WL104B JA	FX1925	FX1857	FX1949	FX1865	FX1873	FX1933	FX1941	FX1849[3]	FX1917
WL164B Q	FX1617	FX1517	FX1609	FX1525	FX1533	FX1565	FX1573[2]		FX1601
WR104B JA					FX1309				

(1) Average of FT1441 and FT1465
(2) Average of FT1549 and FT1573
(3) Average of FT1265 and FT1849

5 FMIN, FMAX, AMPMIN, PHASEMIN, PHASEMAX, NN
(4F8.3, 2F8.2, 15)

6 F(1) AMP(1) PHASE(1) F(2) AMP(2) PHASE(2) F(3) AMP(3)
PHASE(3) 3(2F8.3, F8.2)

\+

\+ data

\+

\+ .....F(NN) AMP(NN) PHASE(NN)

where NN is the number of data points in the set. Table 4 is an example of a data set from file FX1425.

TABLE 4. SAMPLE OF TYPICAL DATA

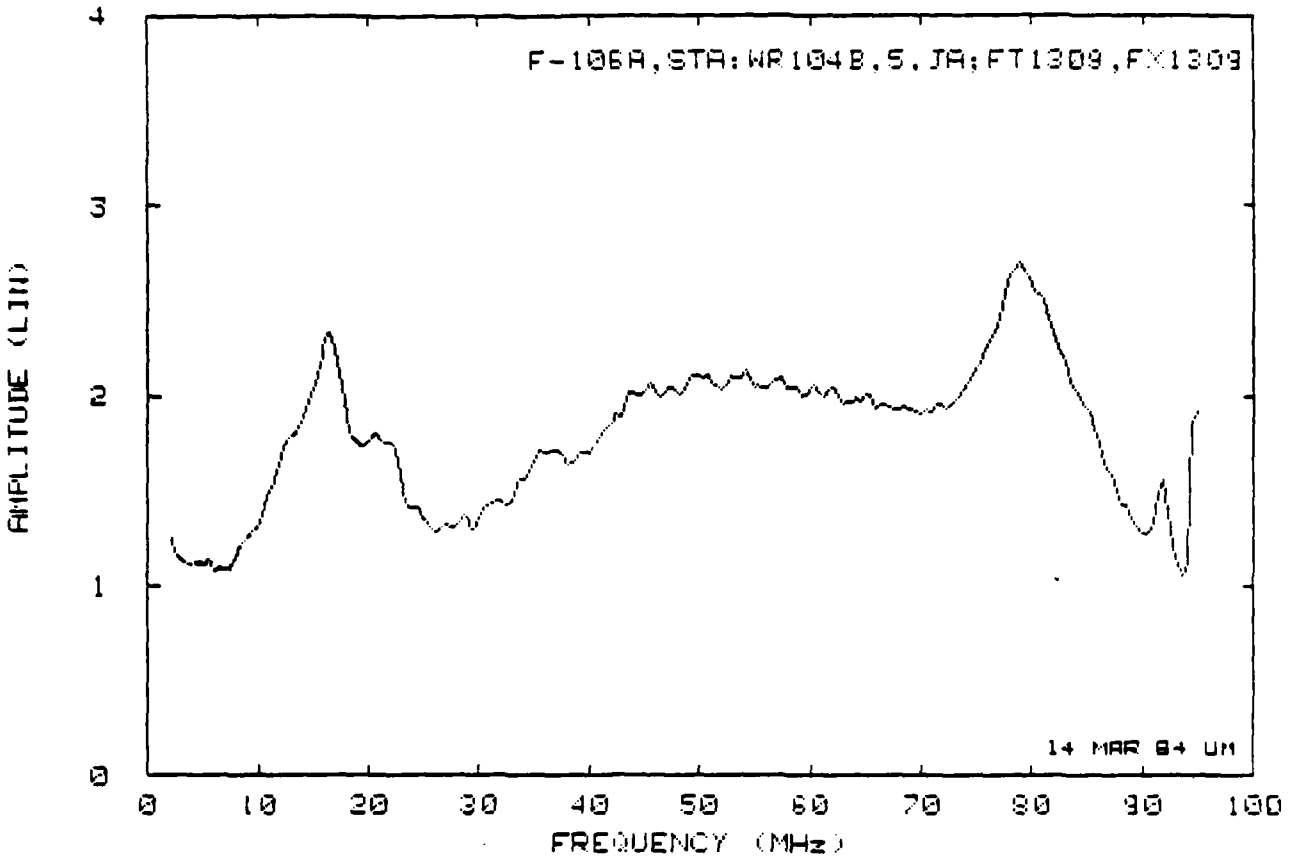
```
  1  FX1425
  2  F-106,VS630L,LFT SIDE INC/-30,0,C/ 03,1 31 84JB...BAND1
  3  Data filtered by FILTR5 Prgm.; Cycles=100
  4  Filtered F-106A,STA:VS630L,5,0;FT1425,FX1425
  5     3.513  95.644     .084    2.573 -183.70  182.96  462
  6     3.513   1.327   18.31     3.566   1.335   18.21    3.618   1.339   18.26
  7     3.671   1.337   18.61     3.723   1.327   19.32    3.775   1.301   20.32
  8     3.828   1.259   21.57     3.880   1.200   23.12    3.933   1.127   24.53
  9     3.985   1.046   25.69     4.038    .971   25.86    4.090    .910   24.78
 10     4.142    .863   22.83     4.195    .833   20.86    4.247    .823   19.09
 11     4.300    .832   17.12     4.352    .851   14.28    4.405    .869   10.60
 12     4.457    .875    6.28     4.510    .858    1.70    4.562    .810   -3.16
 13     4.614    .725   -8.80     4.667    .611  -16.16    4.719    .476  -26.96
 14     4.772    .352  -46.15     4.824    .284  -78.23    4.877    .313 -113.11
 15     4.929    .404 -137.13     4.981    .515 -152.37    5.034    .630 -164.41
 16     5.086    .740 -173.61     5.139    .842  178.79    5.191    .940  172.51
 17     5.244   1.045  167.10     5.296   1.163  161.99    5.348   1.294  156.36
 18     5.401   1.431  151.59     5.453   1.561  146.12    5.506   1.675  140.50
 19     5.558   1.764  134.79     5.611   1.829  128.98    5.663   1.869  123.00
 20     5.716   1.884  116.88     5.768   1.875  110.62    5.820   1.845  104.31
 21     5.873   1.800   98.03     5.925   1.747   91.92    5.978   1.692   85.23
 22     6.030   1.636   81.26     6.083   1.577   77.35    6.135   1.518   74.63
 23     6.187   1.457   73.06     6.240   1.401   72.32    6.292   1.349   71.79
 24     6.345   1.300   71.09     6.397   1.256   69.91    6.450   1.219   67.95
 25     6.502   1.192   65.07     6.555   1.175   61.75    6.607   1.166   56.99
  .
  .
  .
135    64.601    .557   29.77    65.021    .558   30.77   65.440    .576   30.16
136    65.860    .626   30.55    66.279    .647   28.12   66.699    .620   28.59
137    67.118    .627   30.85    67.538    .648   32.91   67.957    .638   32.26
138    68.377    .690   30.31    68.796    .674   30.16   69.216    .696   30.10
139    69.635    .718   28.74    70.055    .727   24.59   70.474    .703   23.83
140    70.894    .693   25.18    71.313    .688   26.94   71.733    .682   28.19
141    72.152    .687   27.35    72.572    .709   29.52   72.991    .694   29.00
142    73.411    .687   27.68    73.830    .680   28.47   74.250    .667   28.18
143    74.669    .696   27.93    75.089    .648   26.91   75.508    .673   26.64
144    75.928    .685   25.09    76.347    .692   20.15   76.767    .719   19.22
145    77.186    .711   18.50    77.606    .716   15.98   78.025    .744   15.11
146    78.445    .752   13.83    78.864    .749   12.77   79.284    .748   14.62
147    79.703    .726   17.39    80.123    .719   16.37   80.542    .707   17.87
148    80.962    .706   20.77    81.381    .671   25.10   81.801    .689   26.53
149    82.220    .653   24.78    82.640    .664   28.65   83.059    .665   27.92
150    83.479    .679   25.81    83.898    .652   25.41   84.317    .658   25.32
151    84.737    .697   24.24    85.156    .683   23.18   85.576    .698   22.42
152    85.995    .714   20.68    86.415    .703   20.94   86.834    .703   17.51
153    87.254    .709   20.39    87.673    .735   20.48   88.093    .720   19.18
154    88.512    .731   18.08    88.932    .746   14.99   89.351    .744   16.30
155    89.771    .752   14.92    90.190    .757   13.24   90.610    .745   12.87
156    91.029    .733   11.80    91.449    .740   15.03   91.868    .756   13.76
157    92.288    .746   14.30    92.707    .754   16.33   93.127    .713   15.57
158    93.546    .707   19.31    93.966    .738   21.34   94.385    .757   21.37
159    94.805    .770   22.10    95.224    .916   23.73   95.644    .860   28.16
```

V. CONCLUSIONS AND RECOMMENDATIONS

The measurements performed on a scale model aircraft have provided data for the exterior response of NASA F-106B at locations where lightning sensors are located on the aircraft. These data can now be used (after substantial data processing) to determine the effect of the aircraft interaction with the lightning generated signals. It is also conceivable that these data, in certain cases, can be used to deconvolute or remove the aircraft interactions from the measured data to give true lightning signal signature.

The data measured and provided herein cover about 2 to 95 MHz range. Since the lightning spectrum extends down to DC, it would also be appropriate to provide data at low frequencies. In the anechoic chamber this is not feasible, but currently a low frequency magnetostatic measurement facility is being developed to perform such measurements and it is expected to provide data in 60 to 500 kHz range.

VI. DATA PLOTS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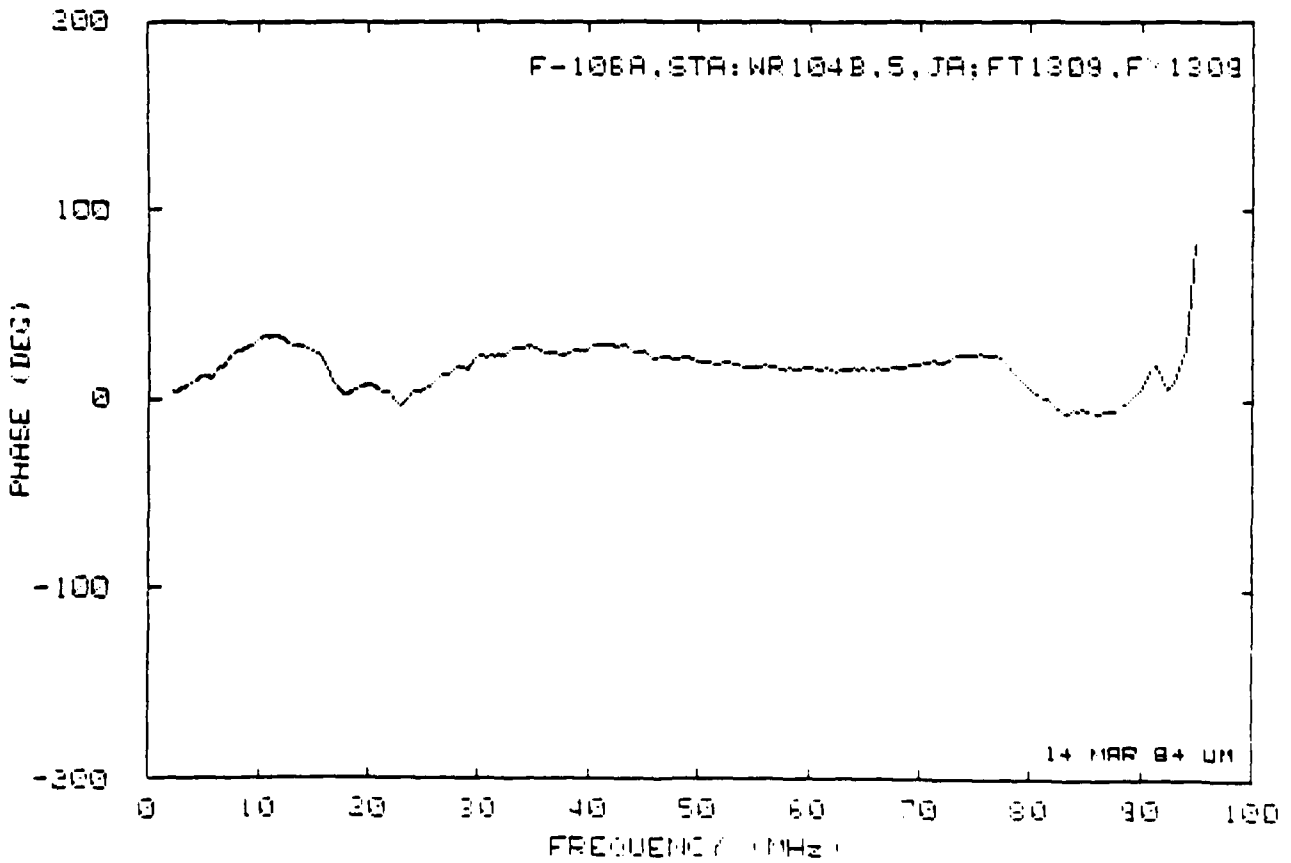
FREQUENCY (MHz)
14 MAR 84 UM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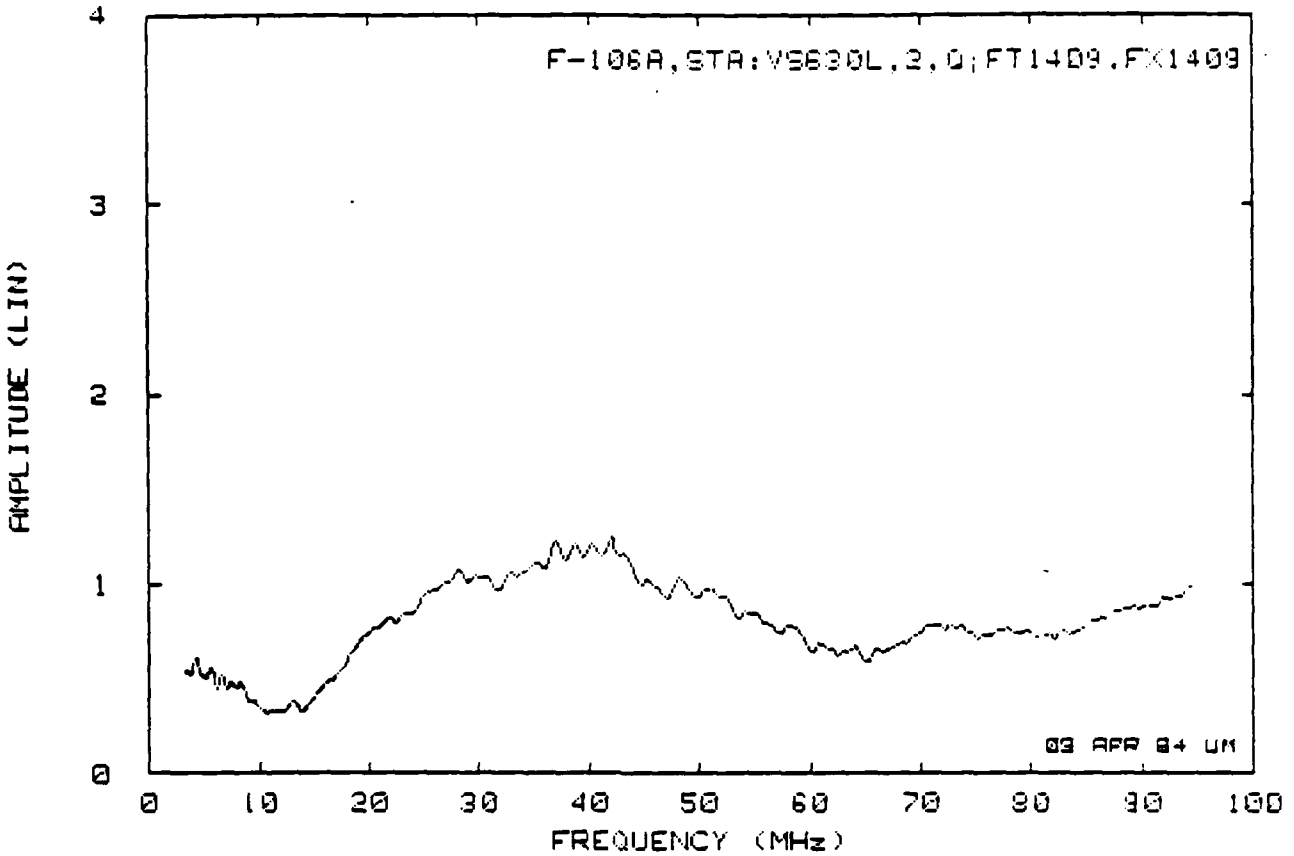
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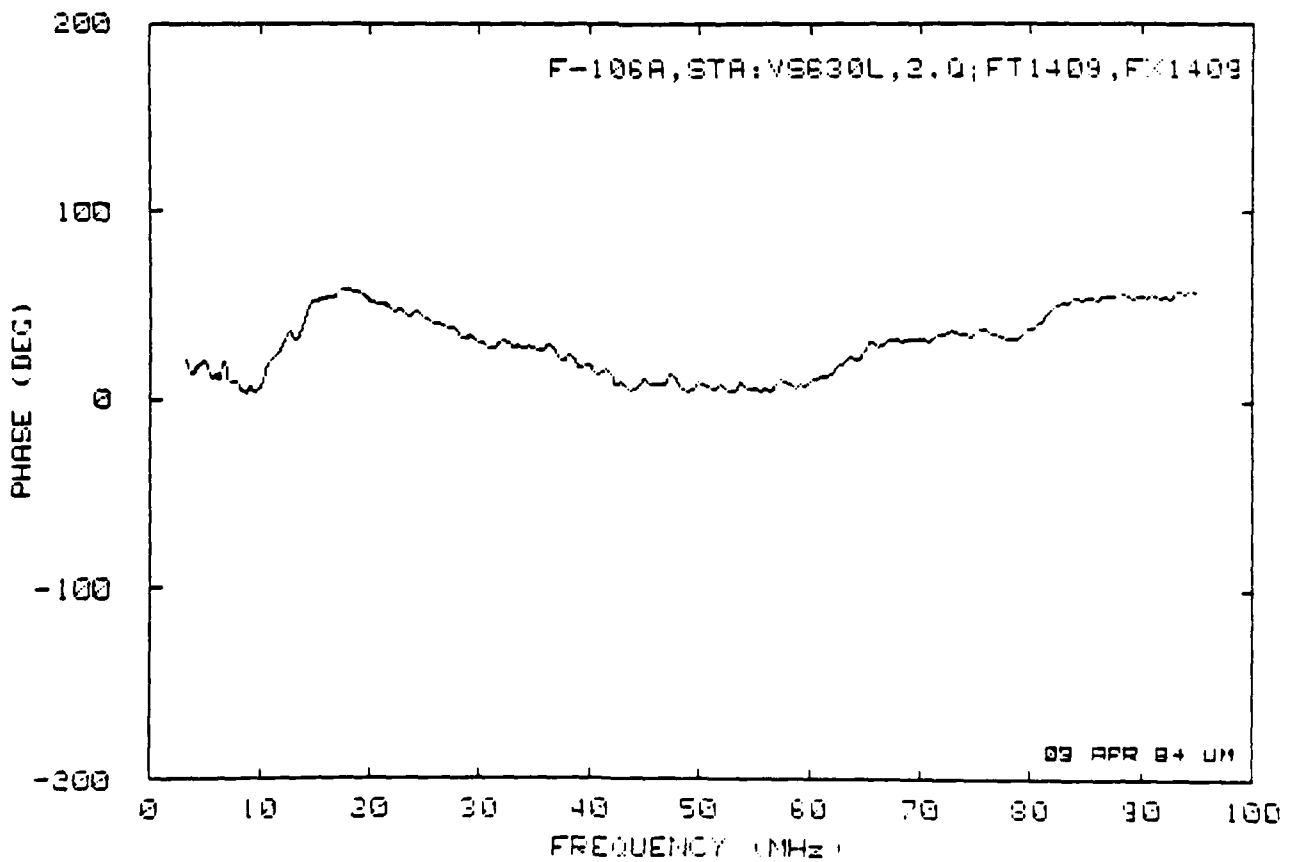
03 APR 84 UM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100
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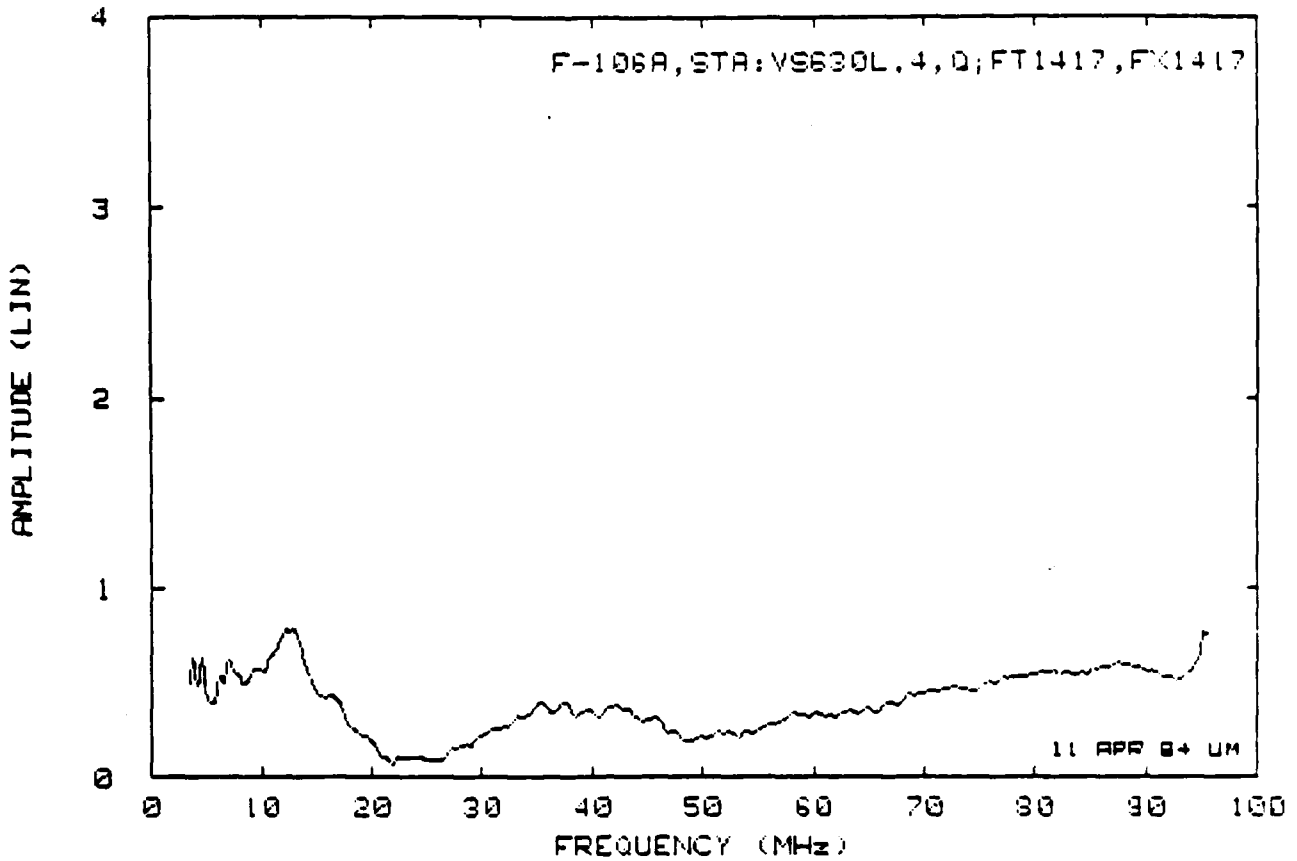
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90
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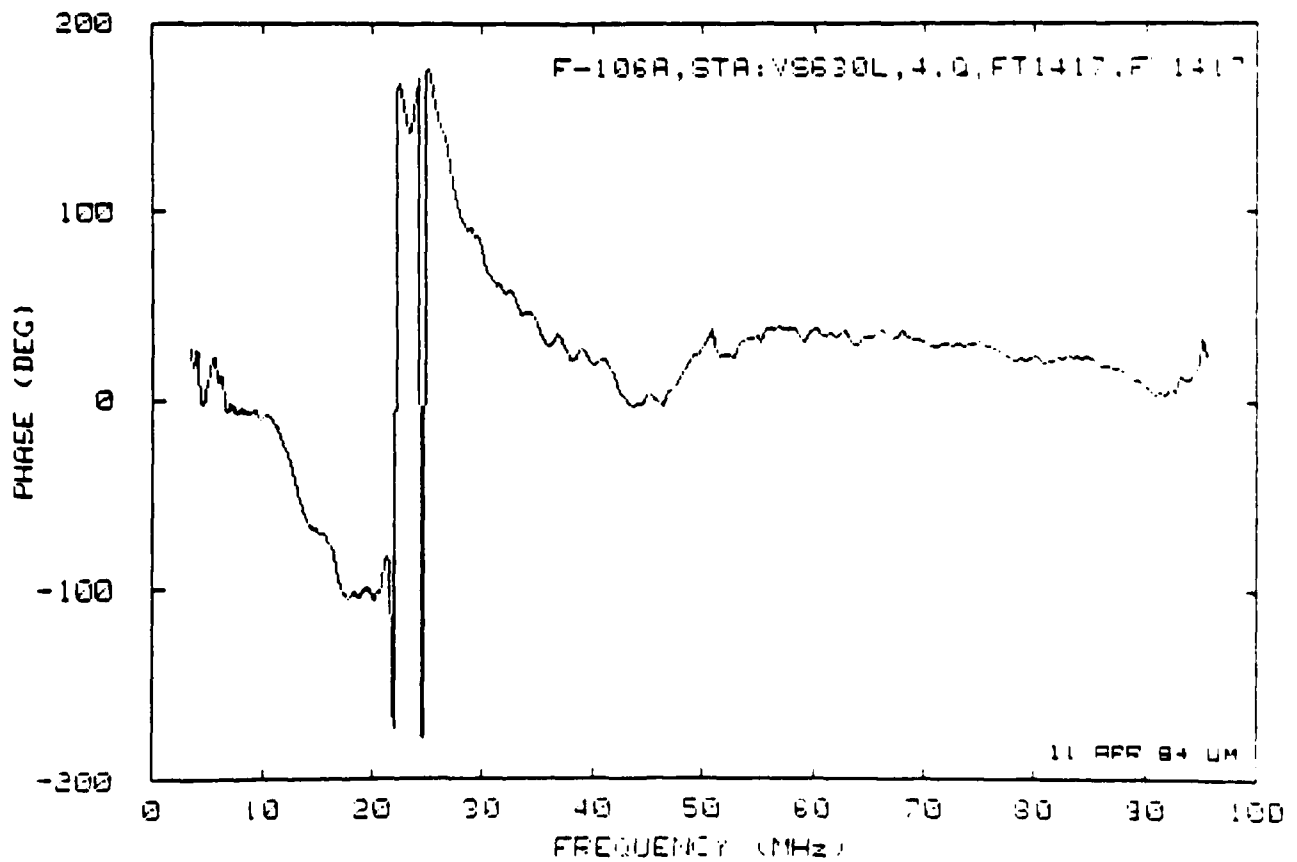
11 APR 84 UM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100
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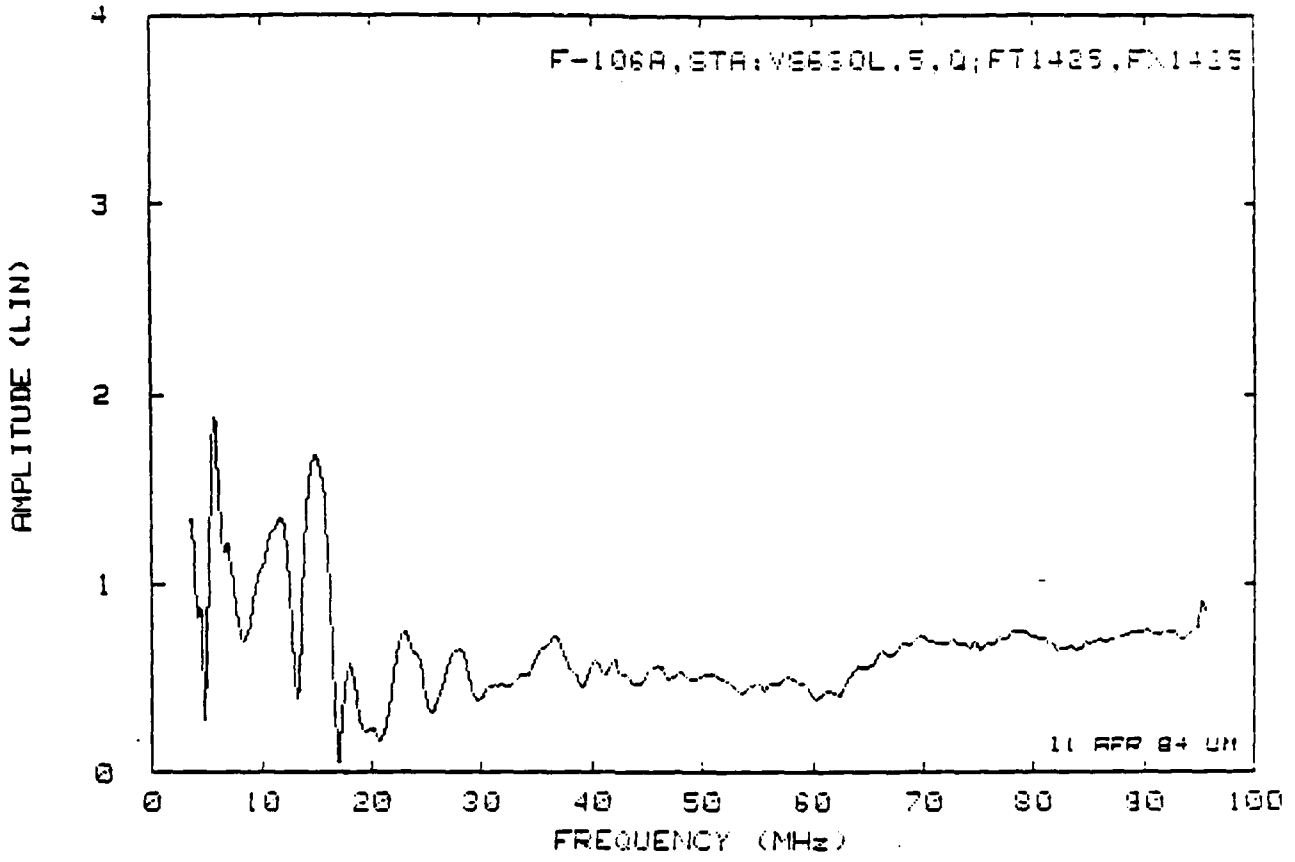
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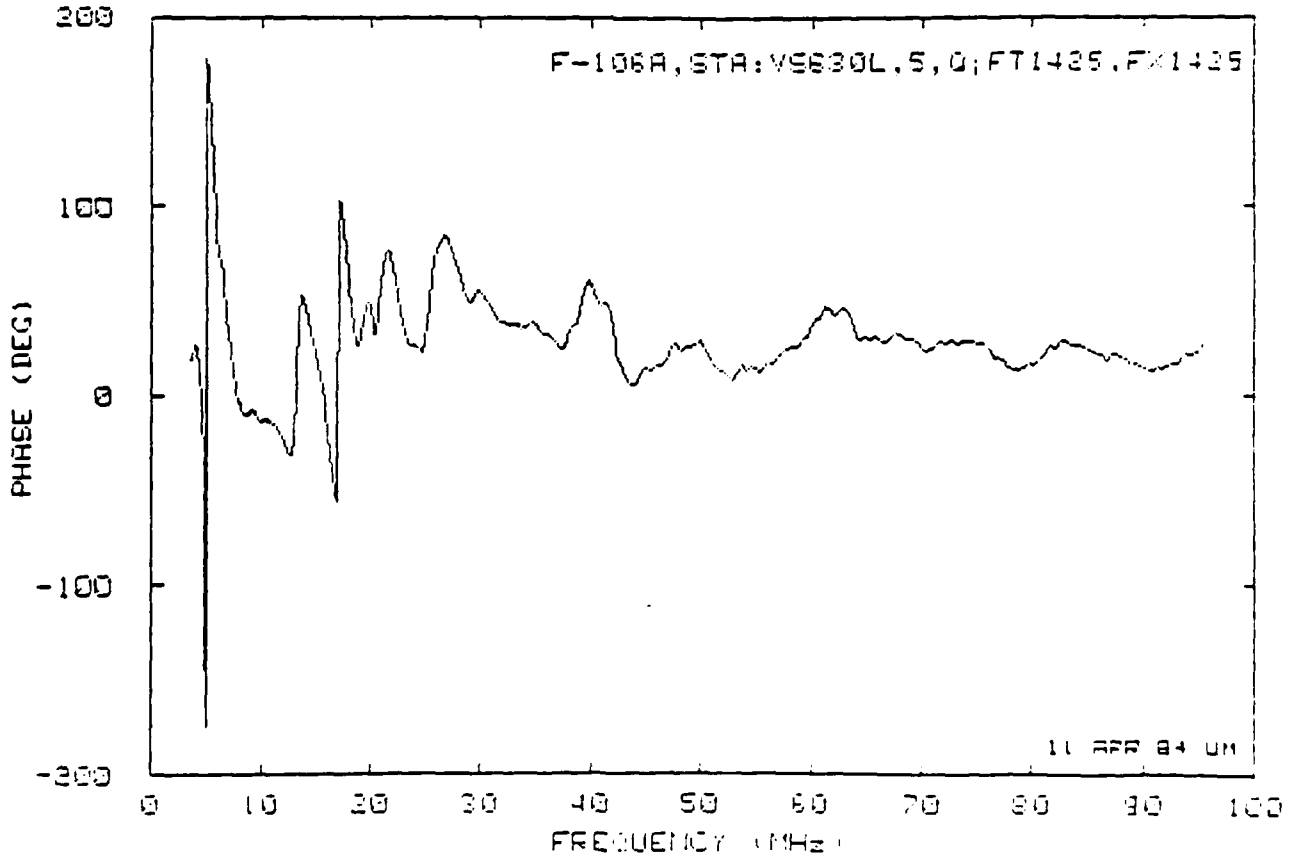
100
FREQUENCY (MHz)
11 APR 84 UM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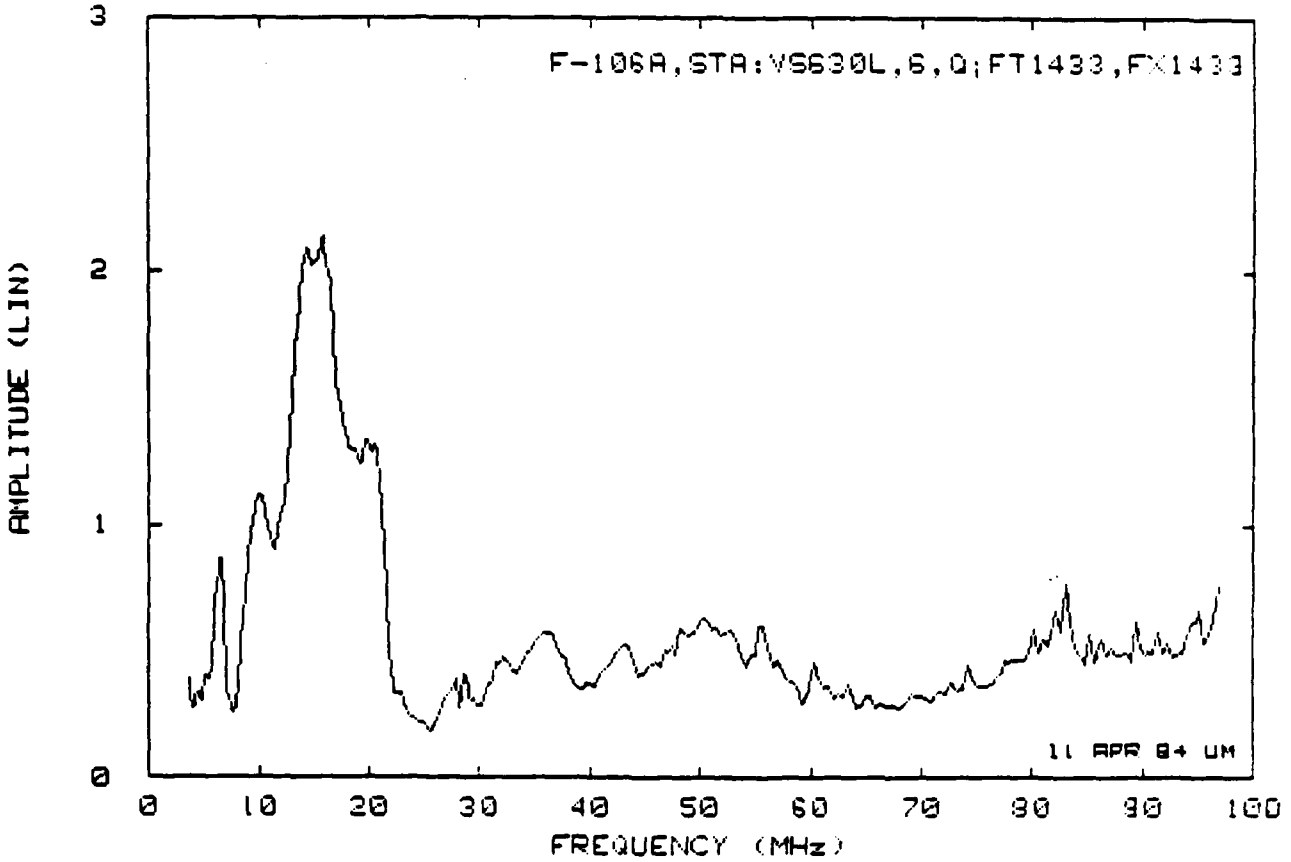
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FREQUENCY (MHz)
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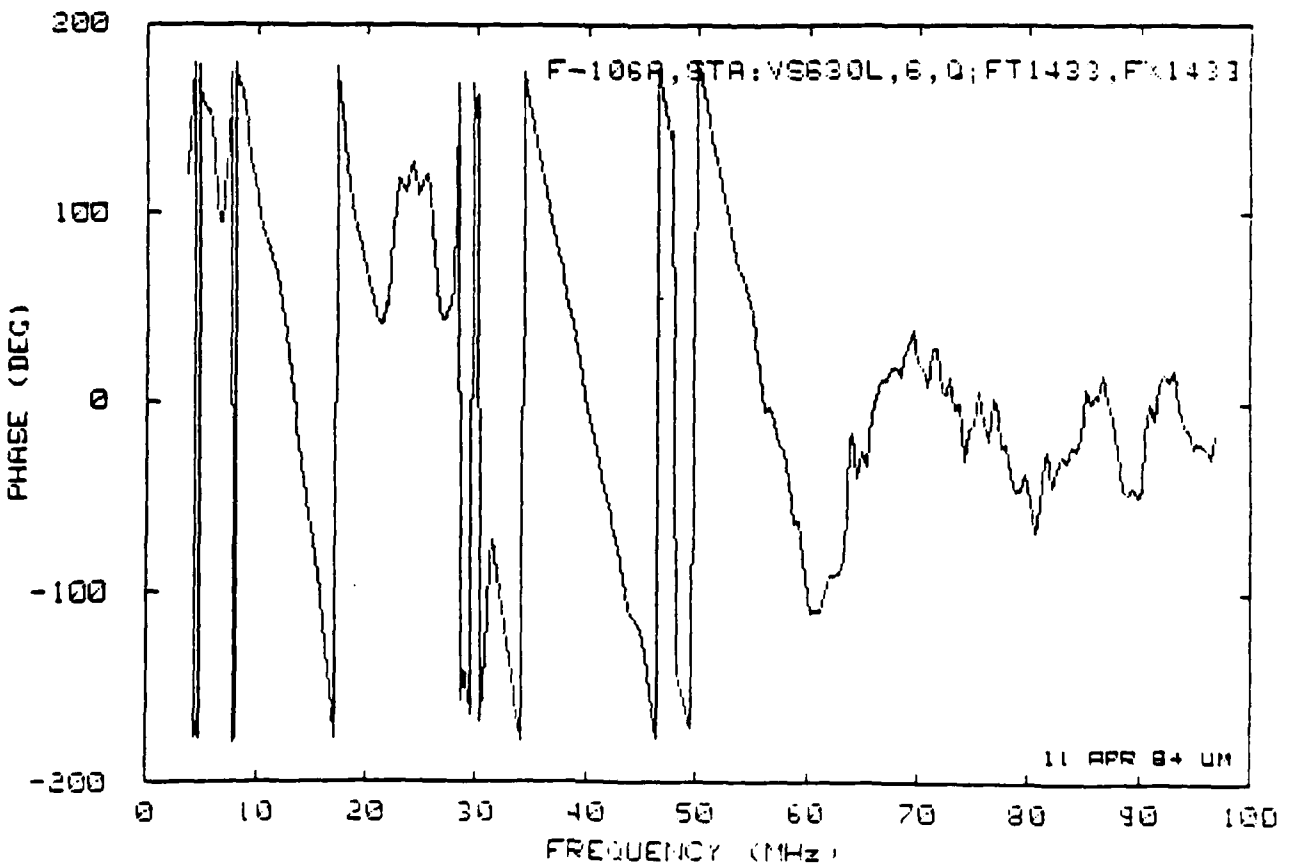
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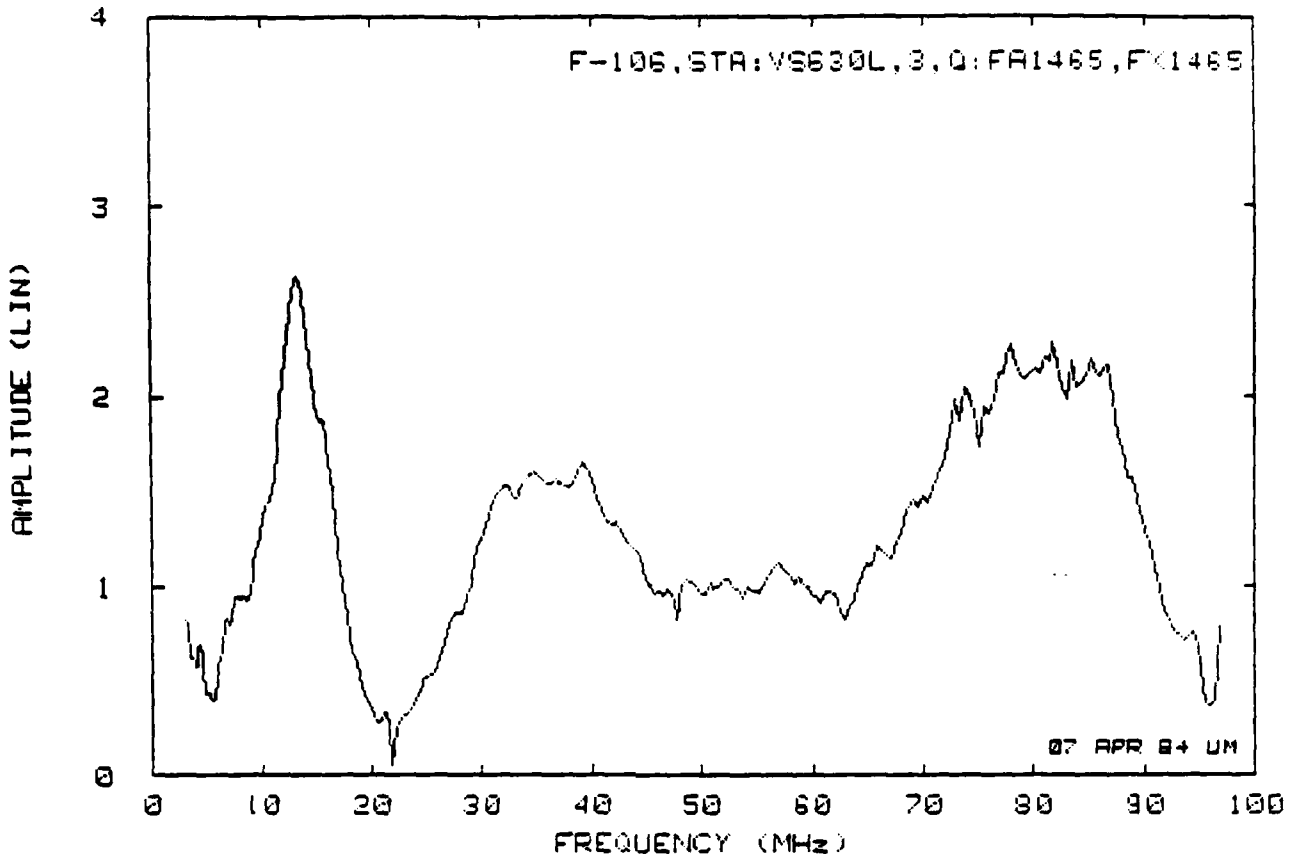
11 APR 84 UM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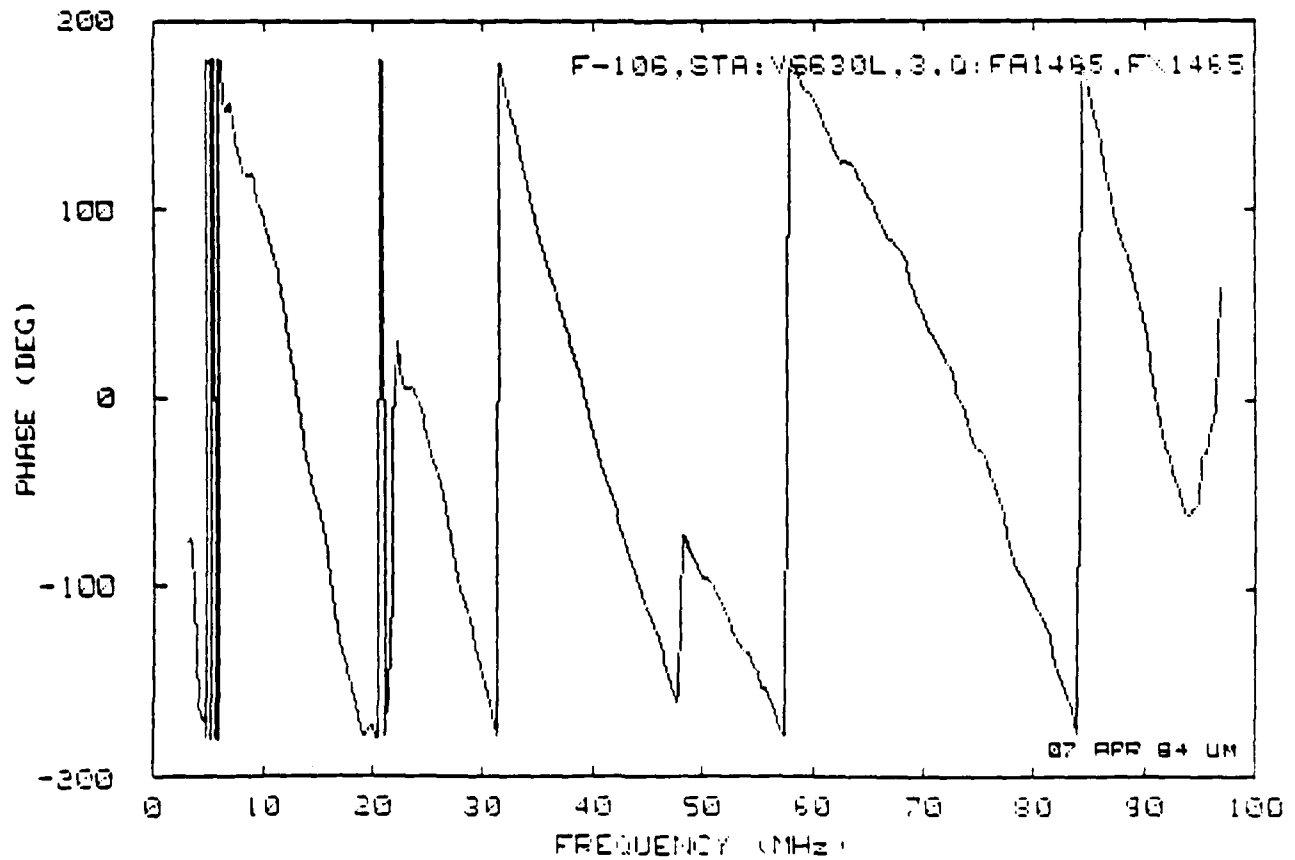
07 APR 84 UM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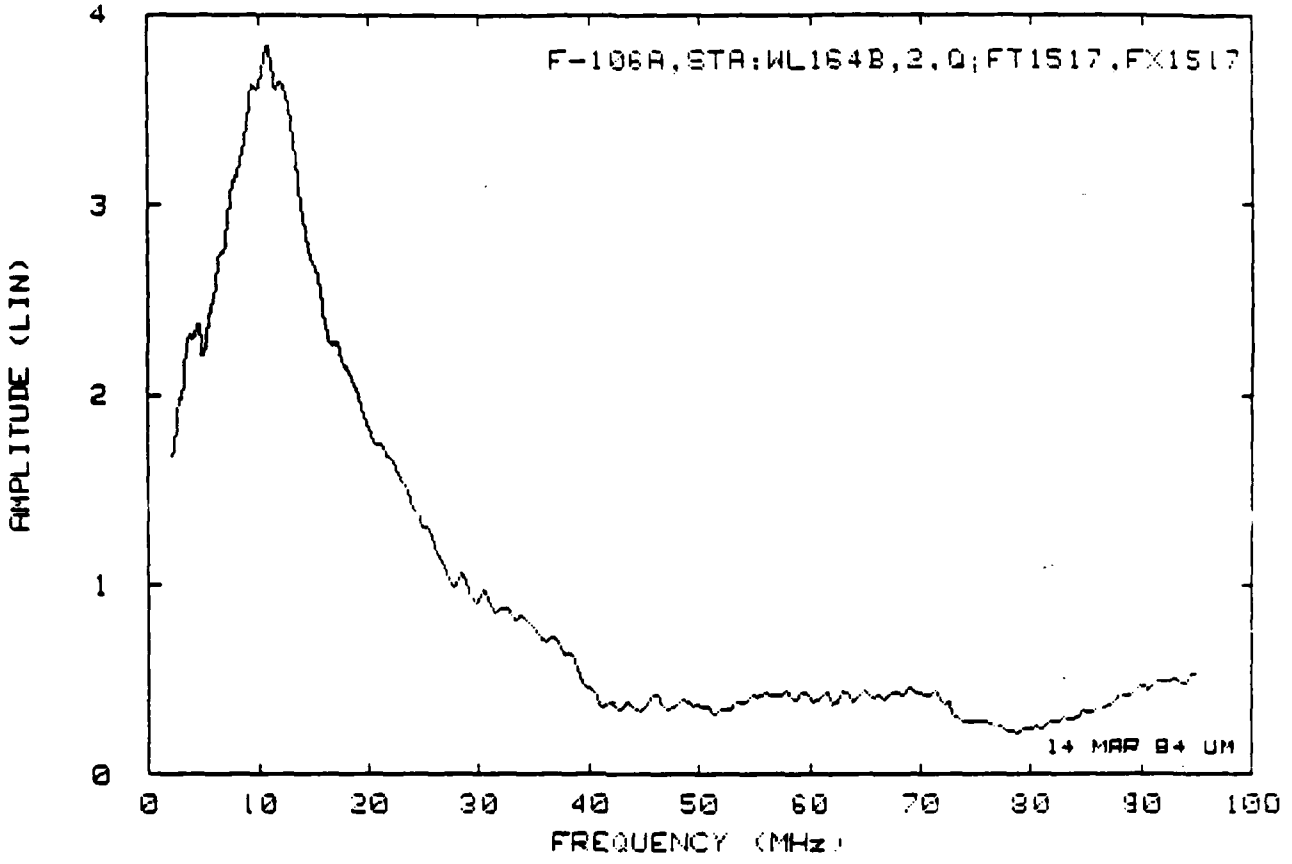
07 APR 84 UM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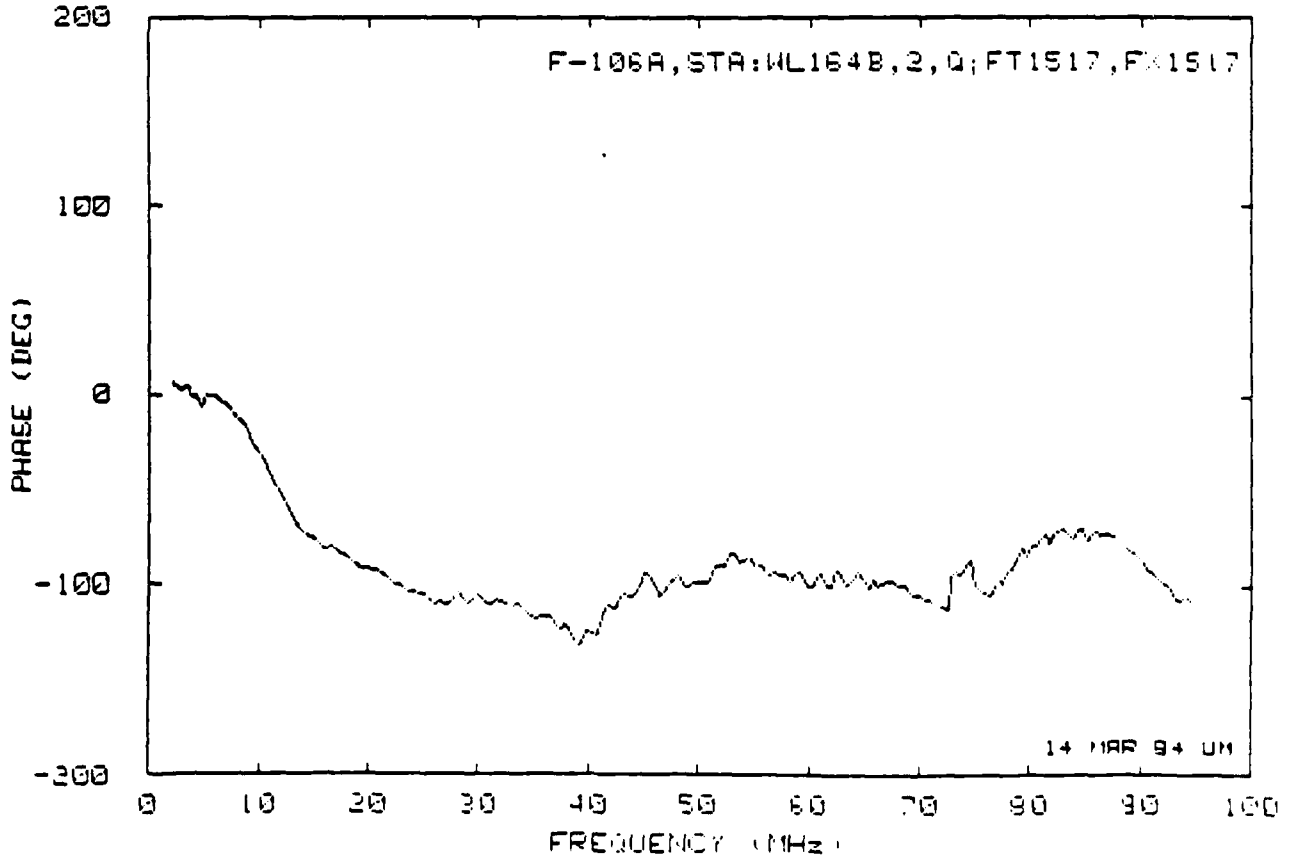
14 MAR 84 UM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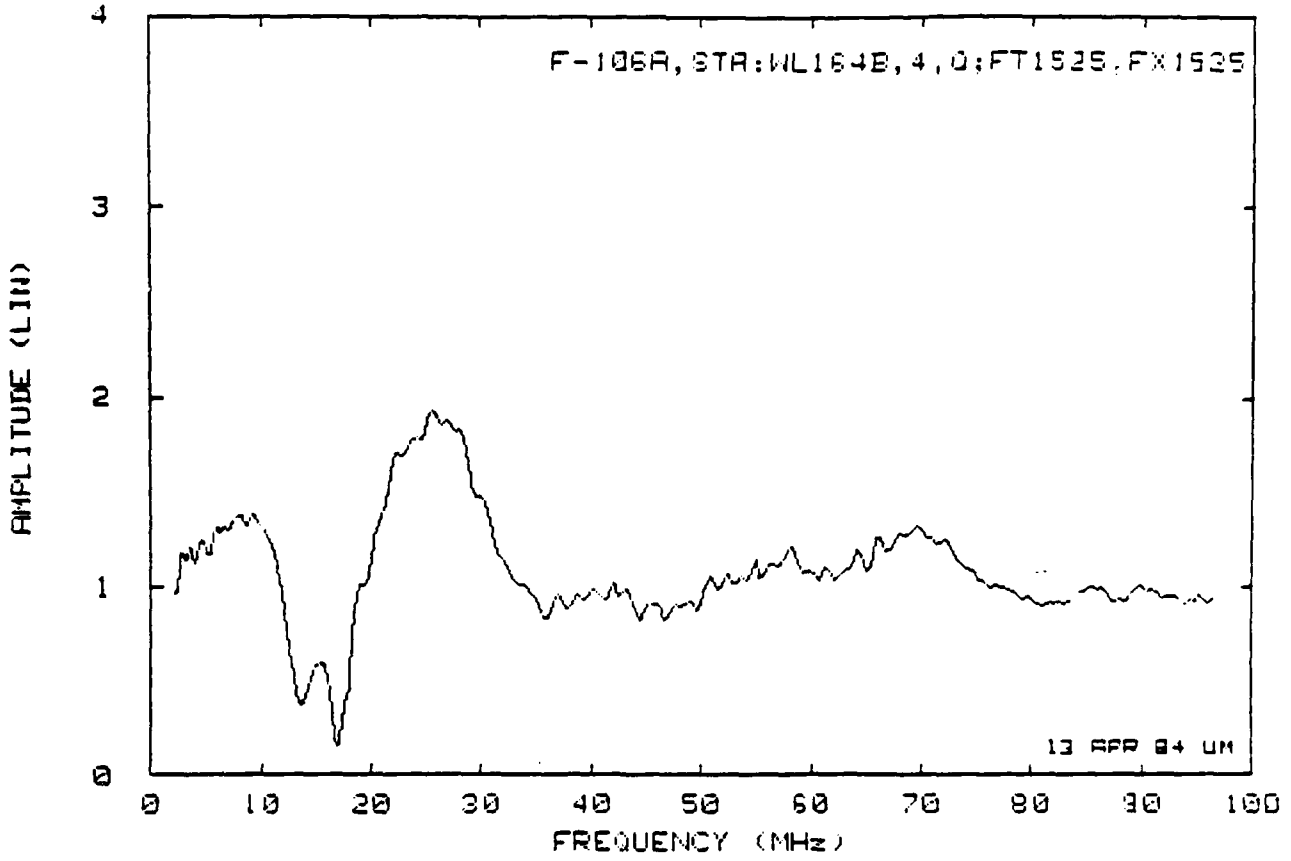
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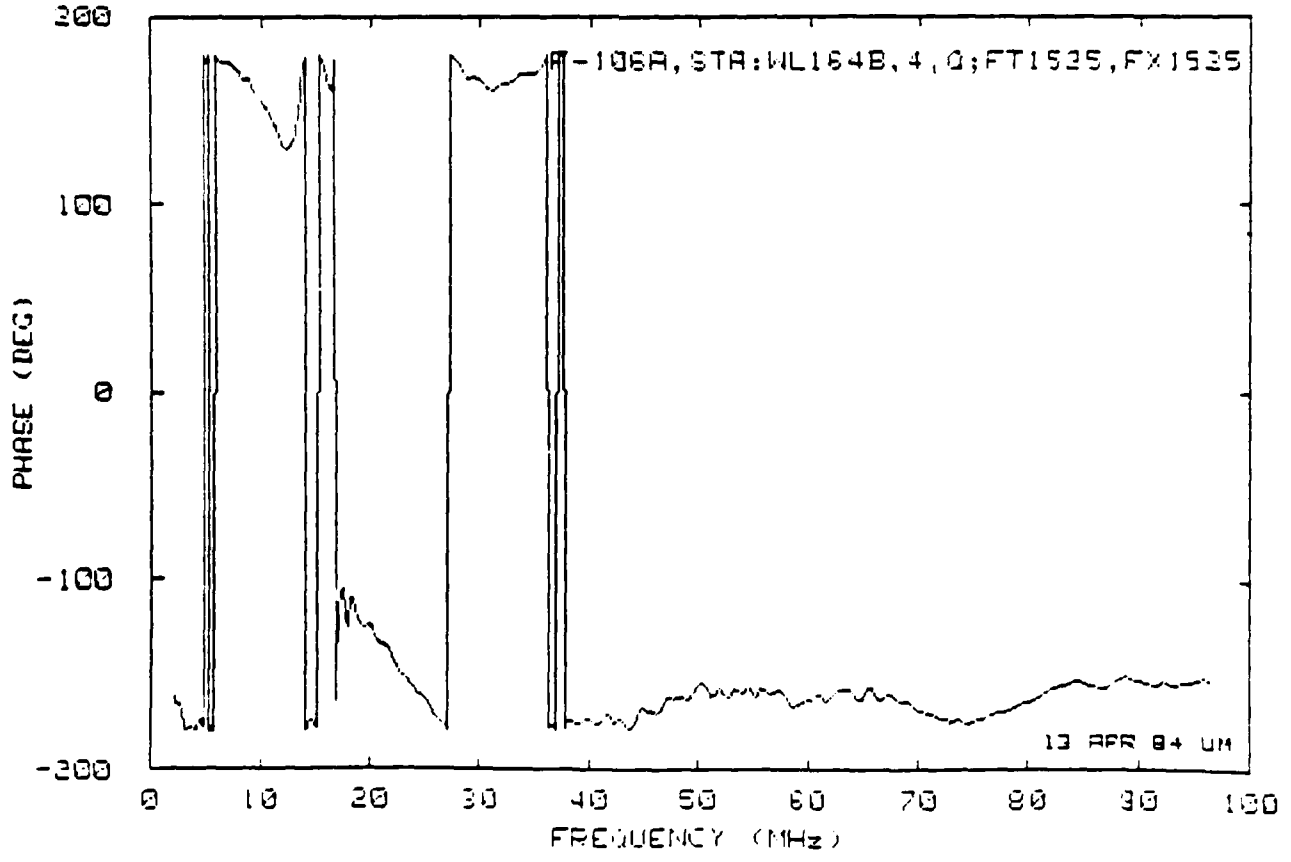
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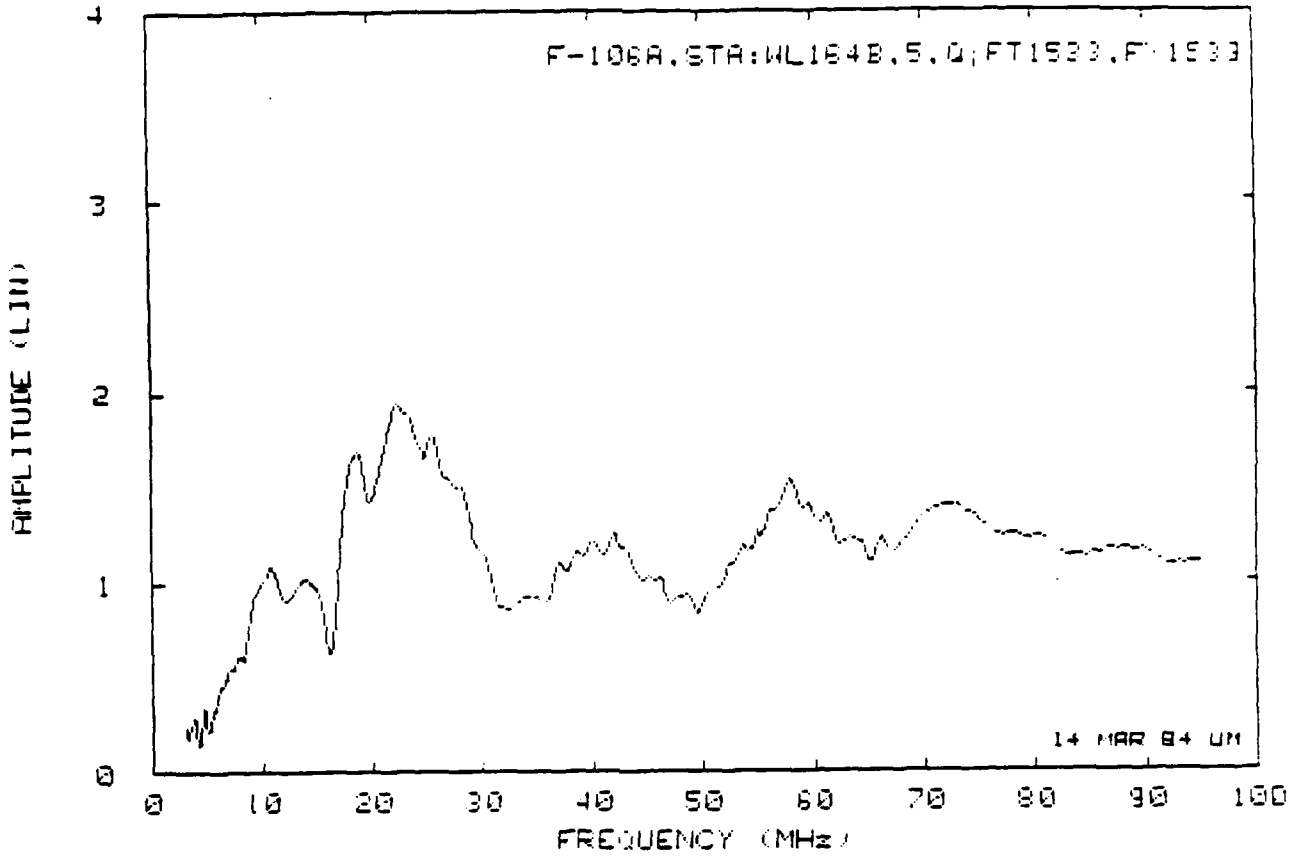
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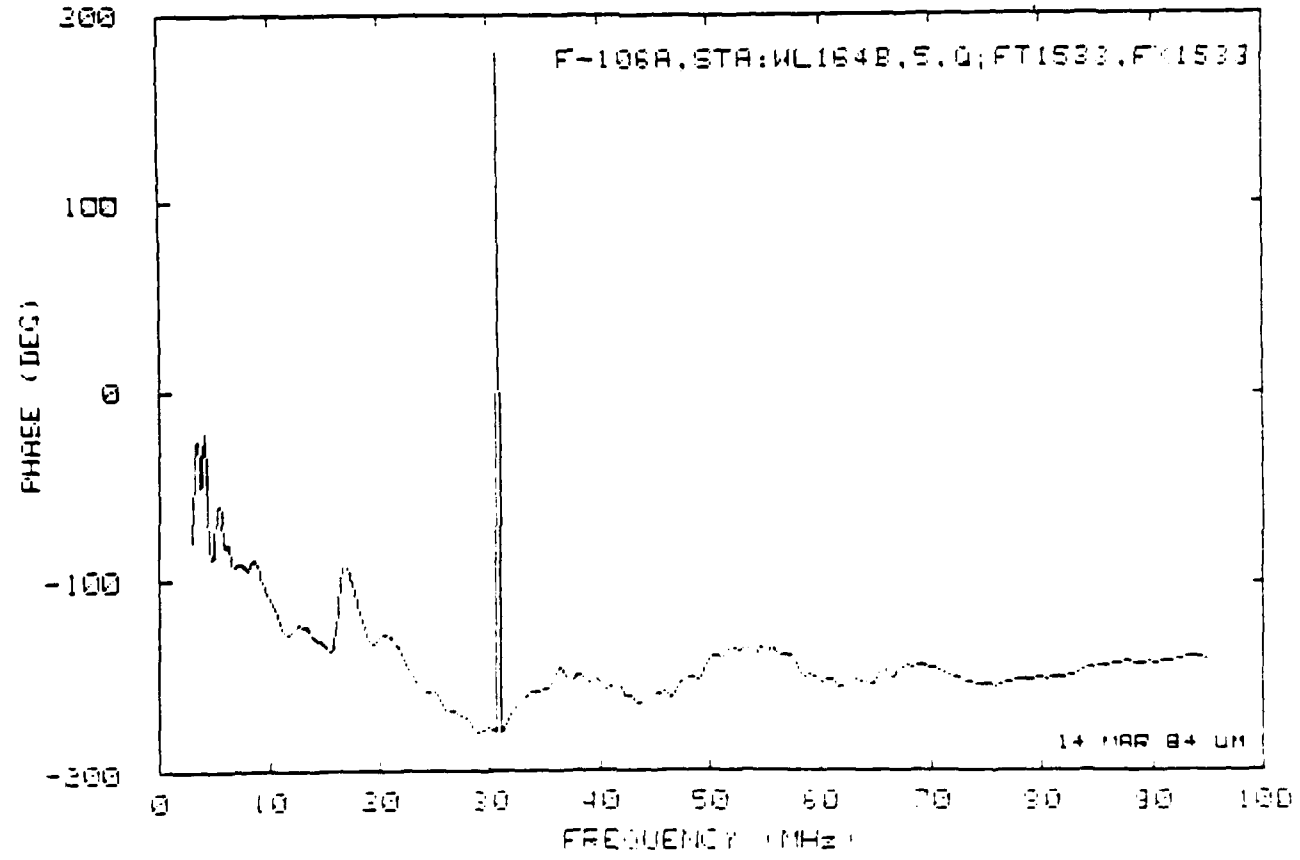
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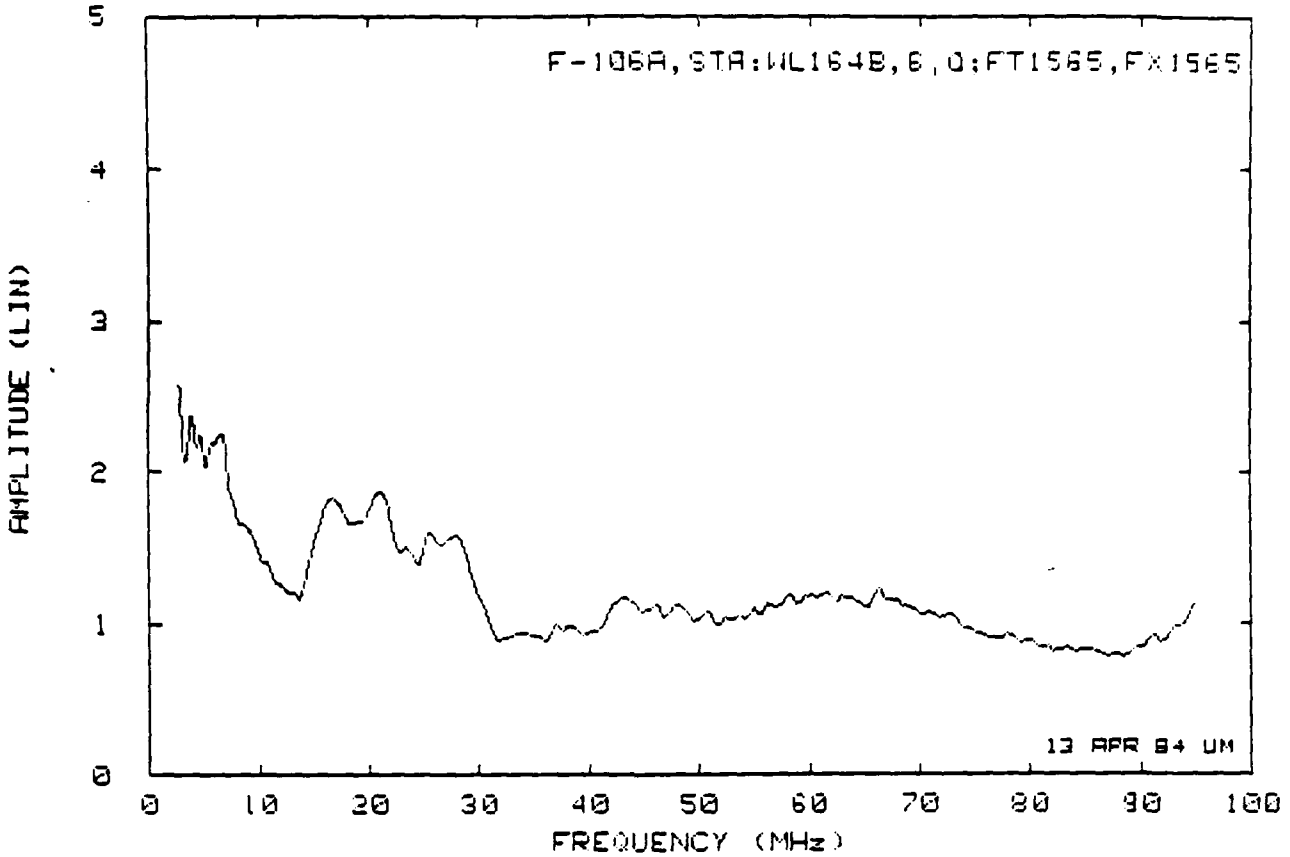
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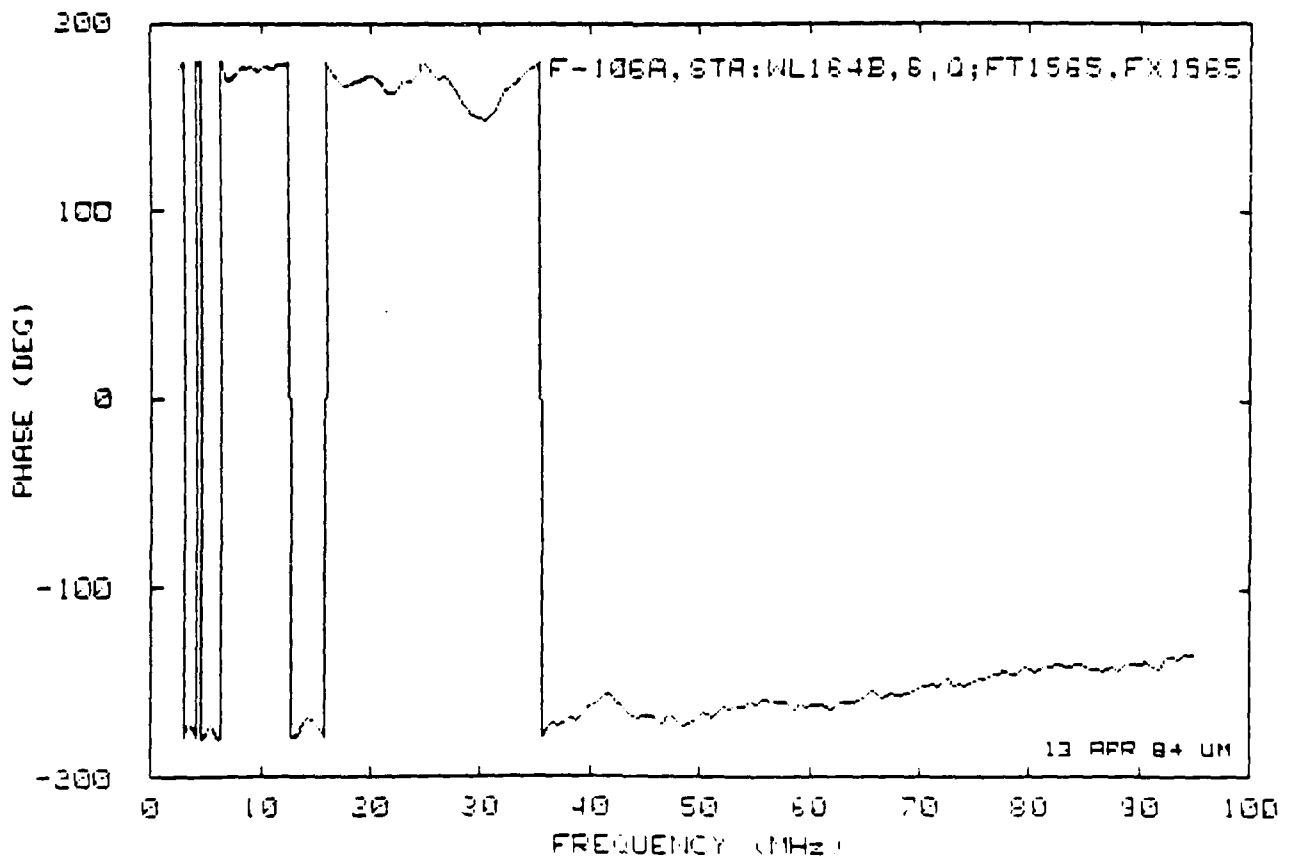
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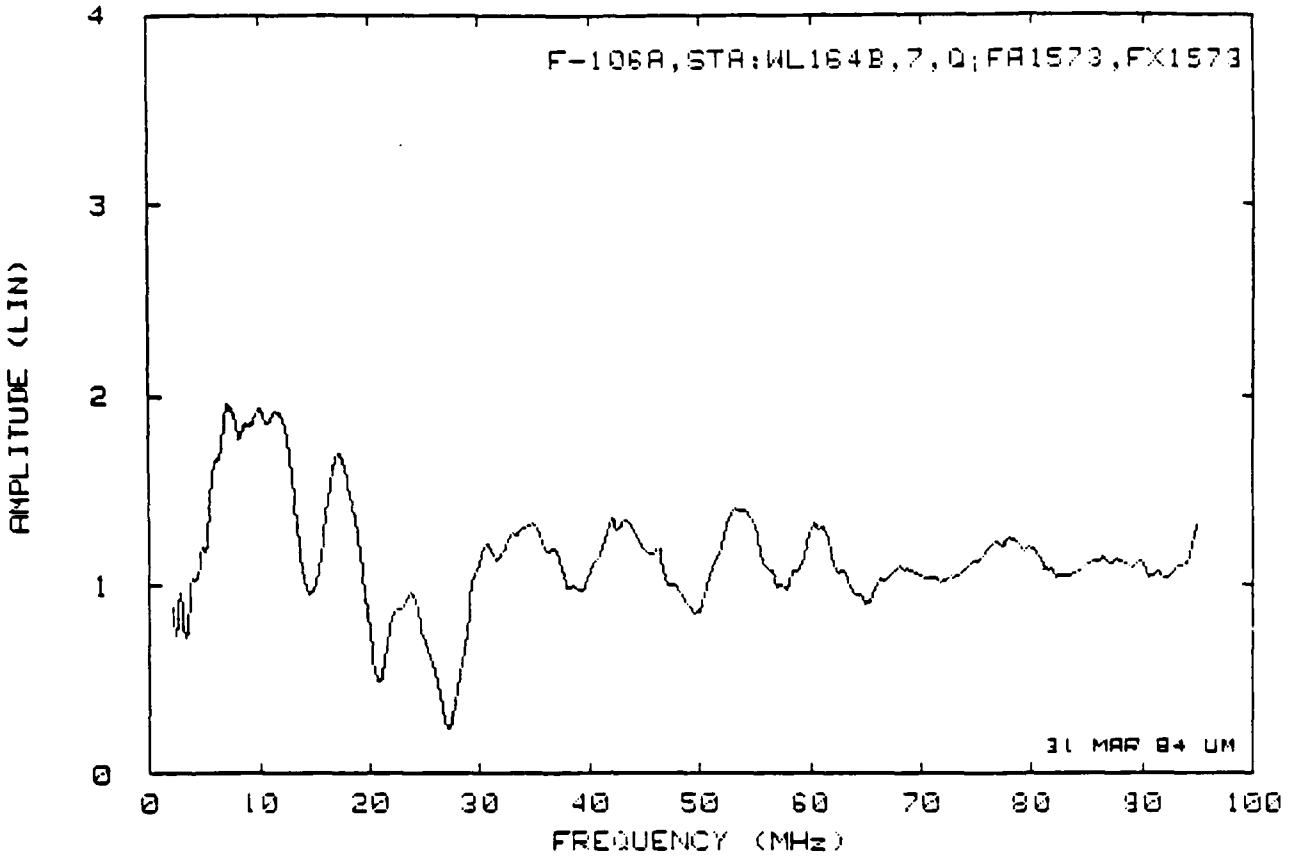
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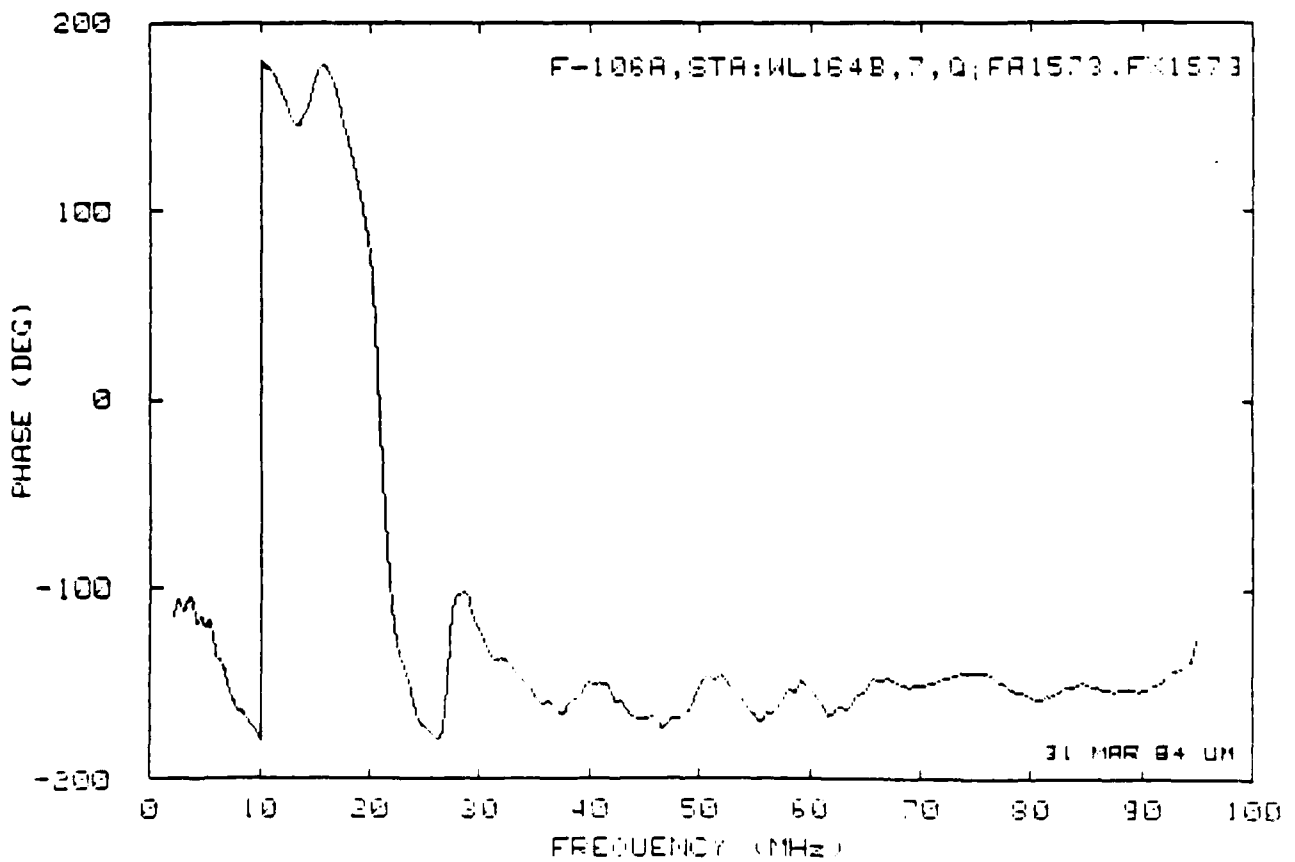
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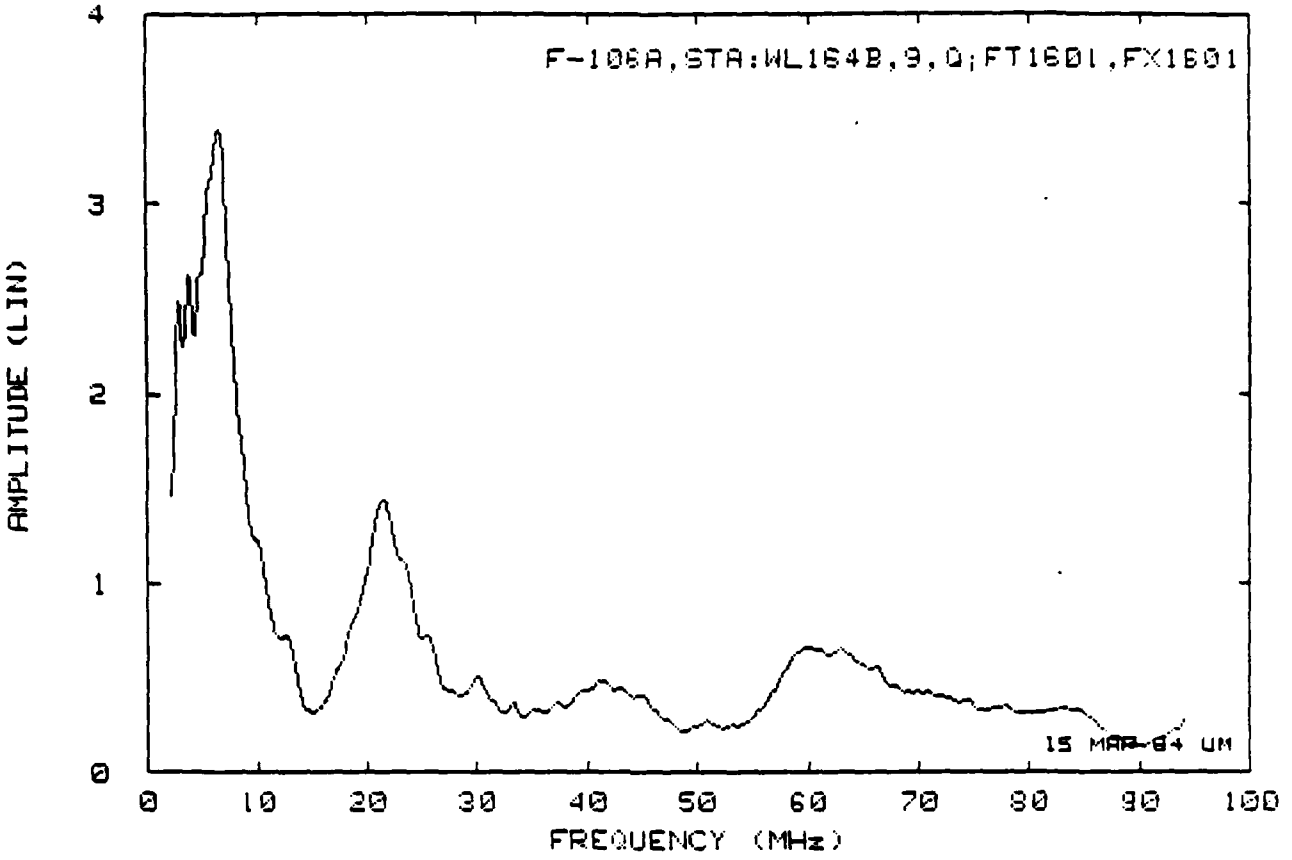
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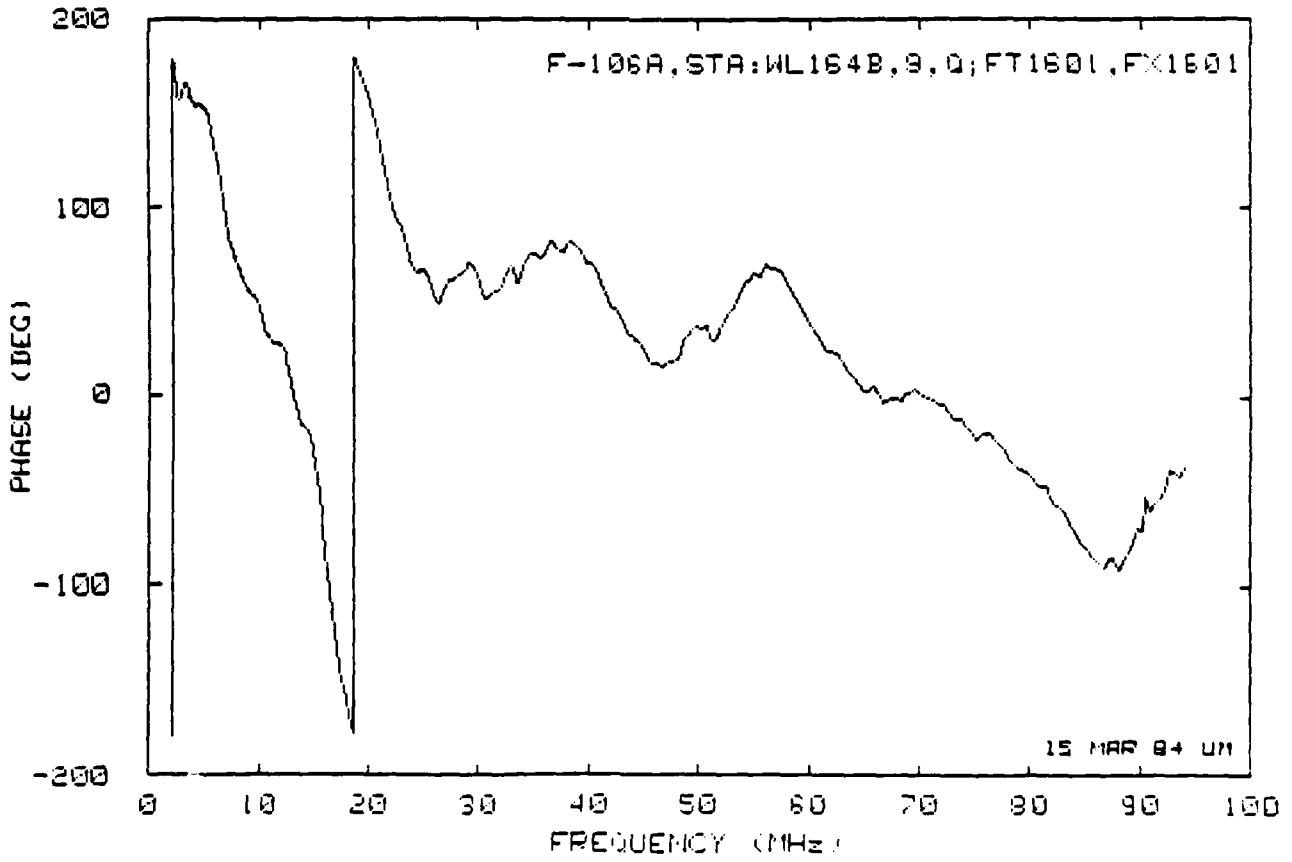
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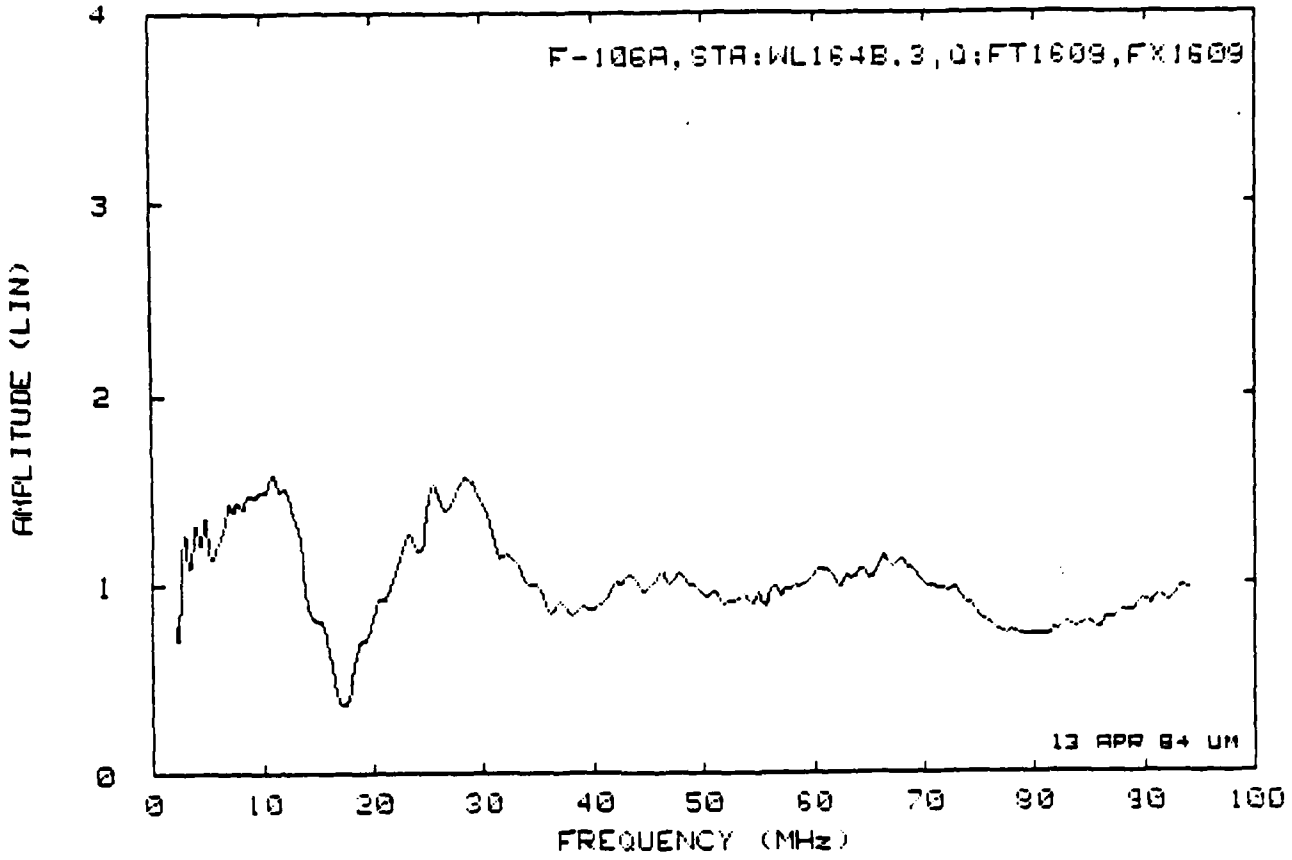
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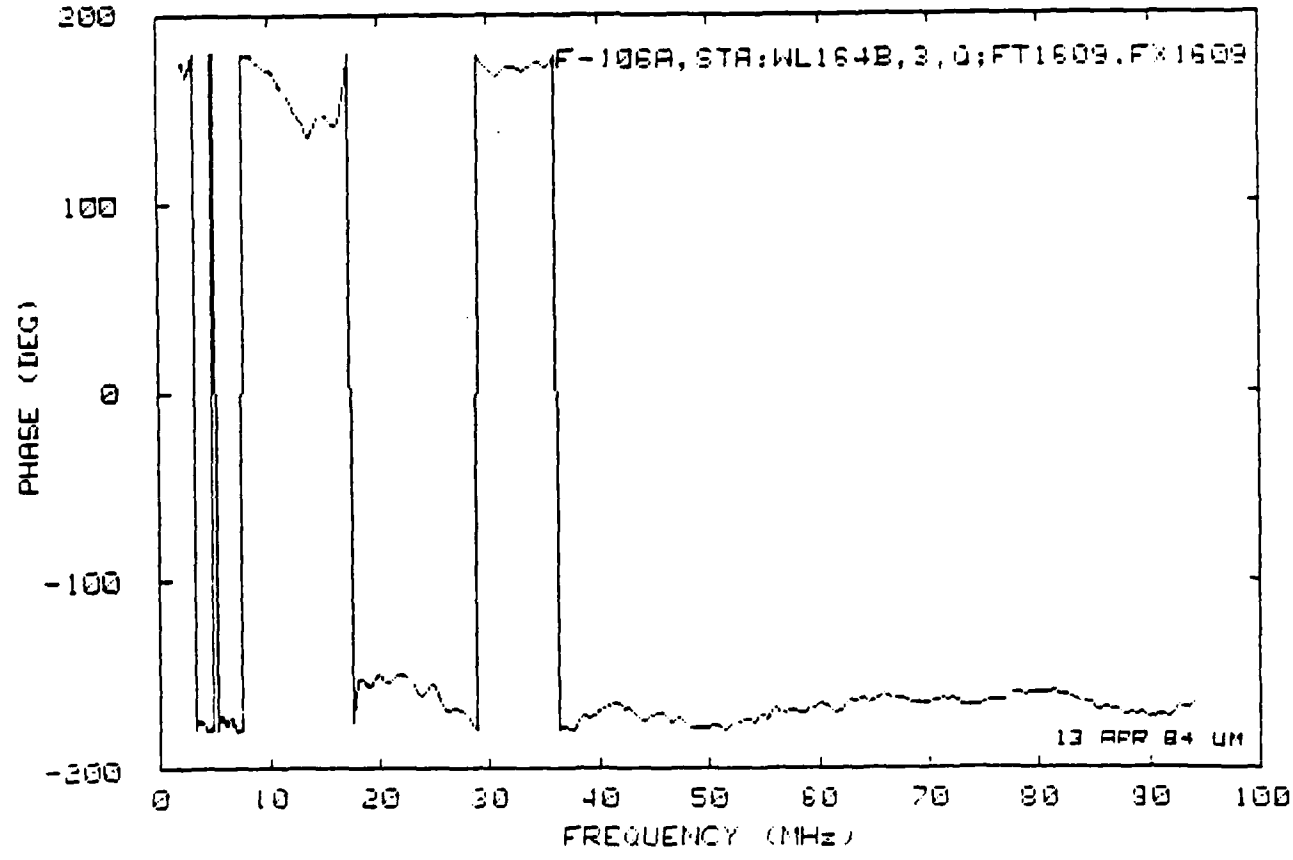
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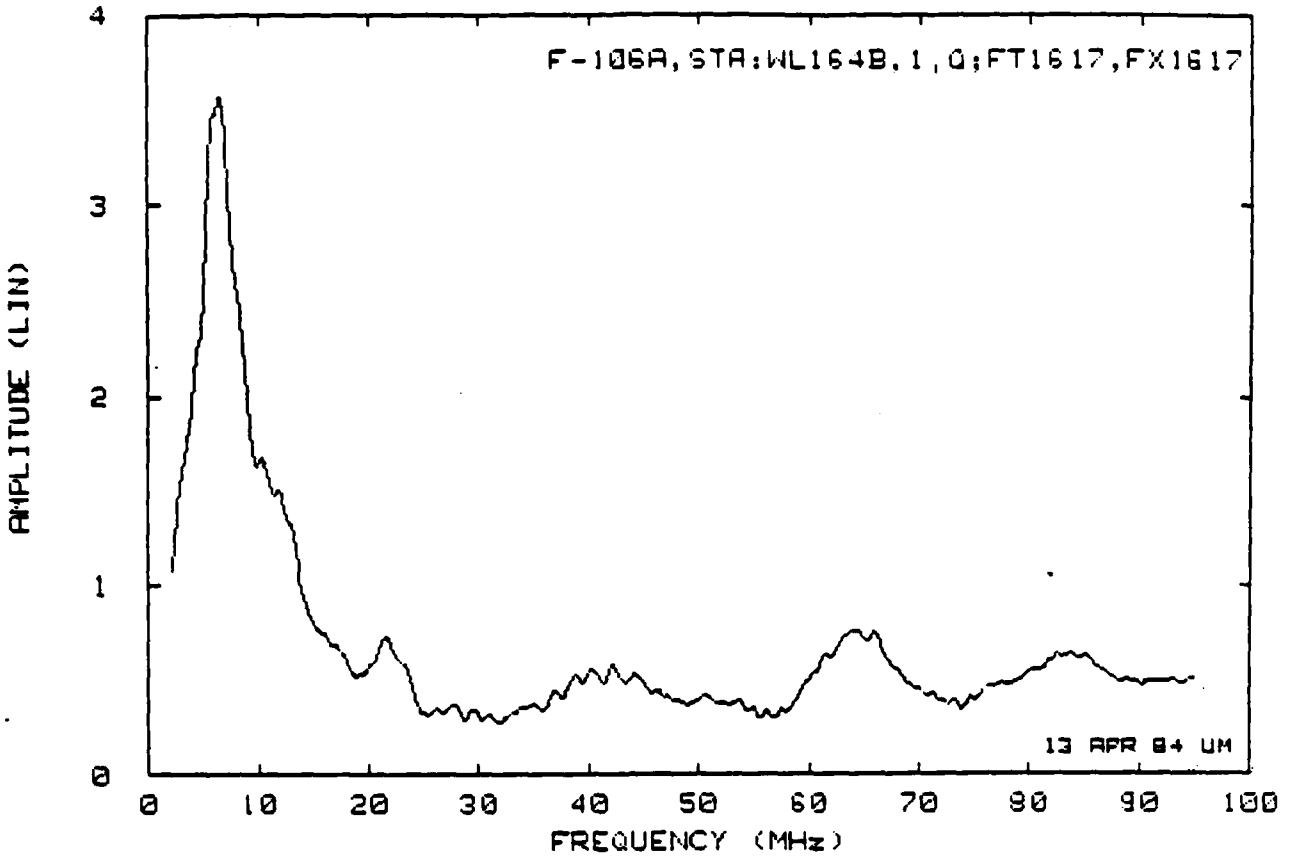
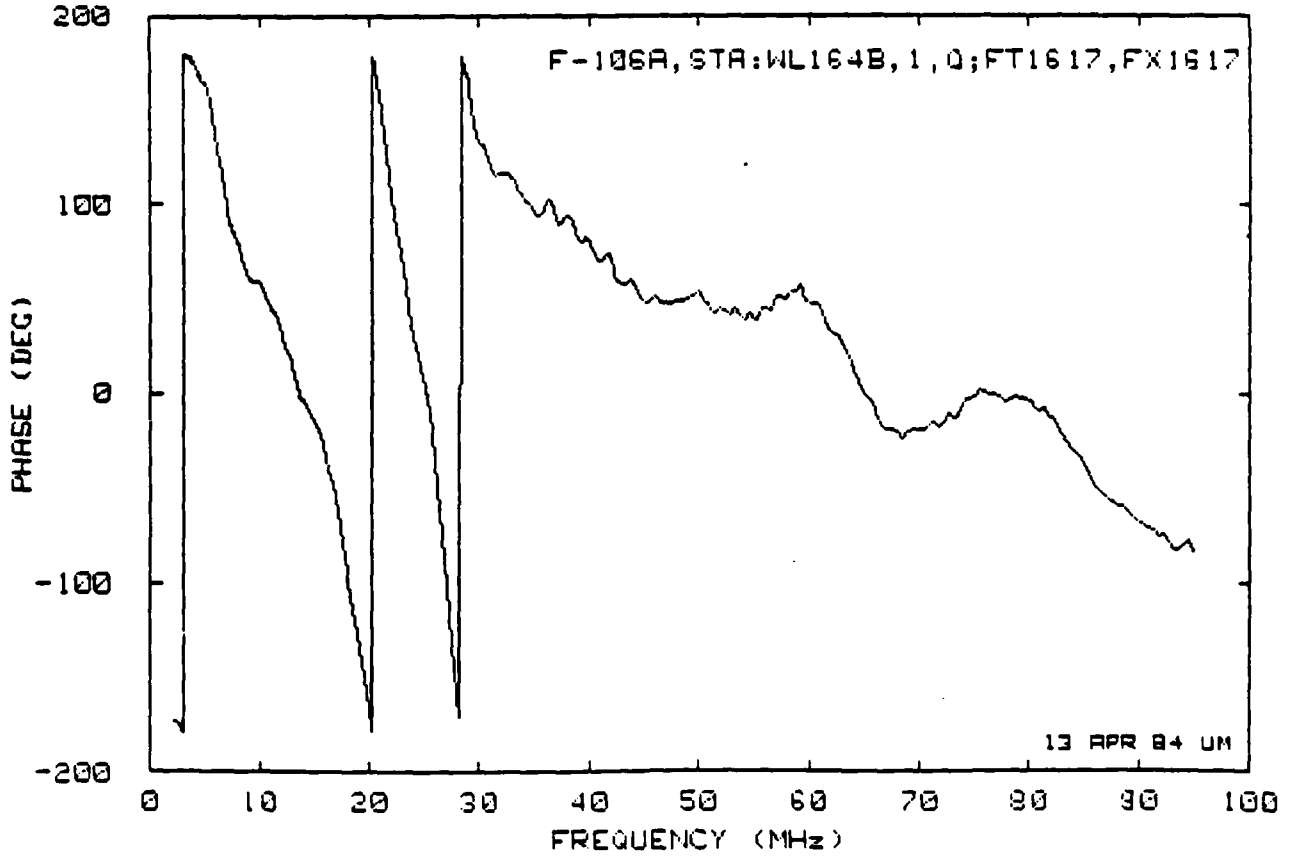
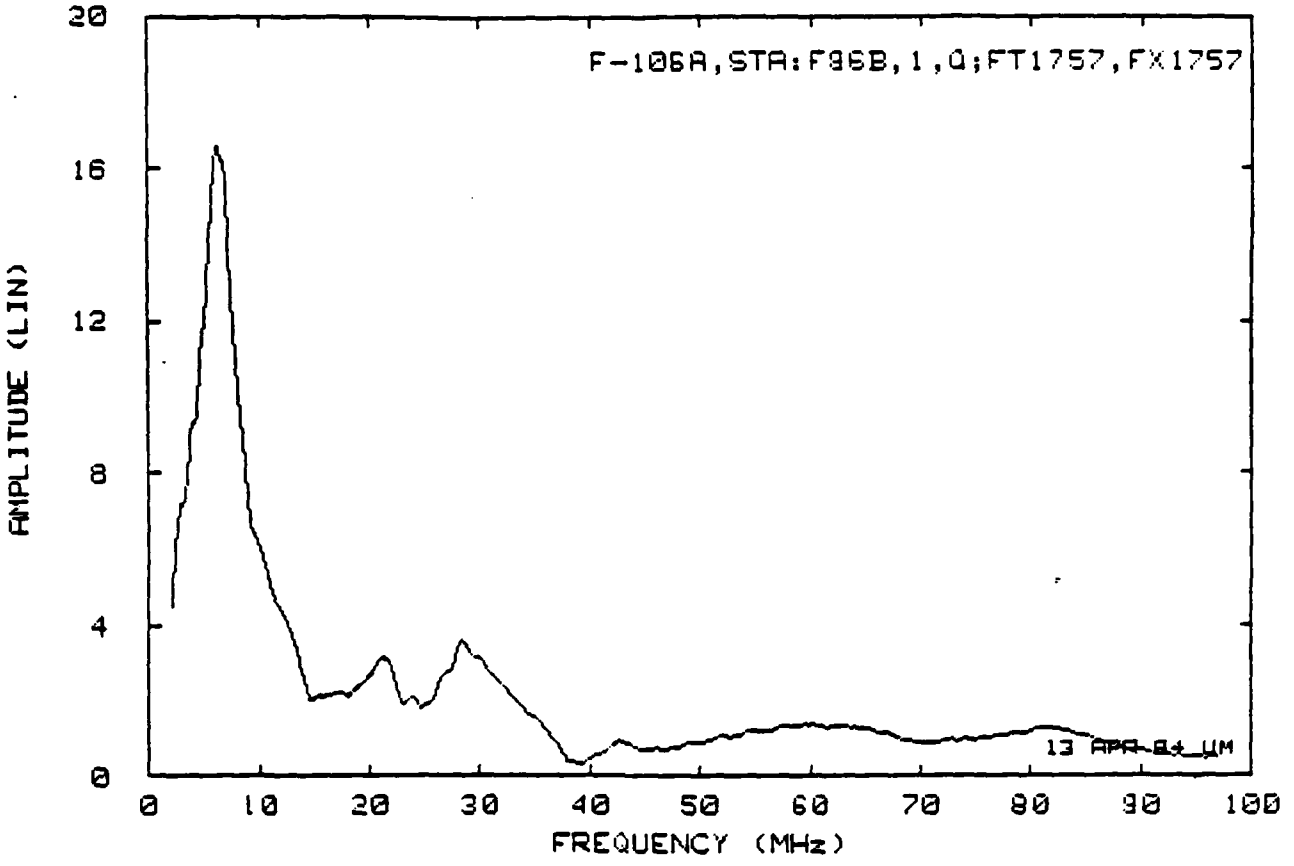
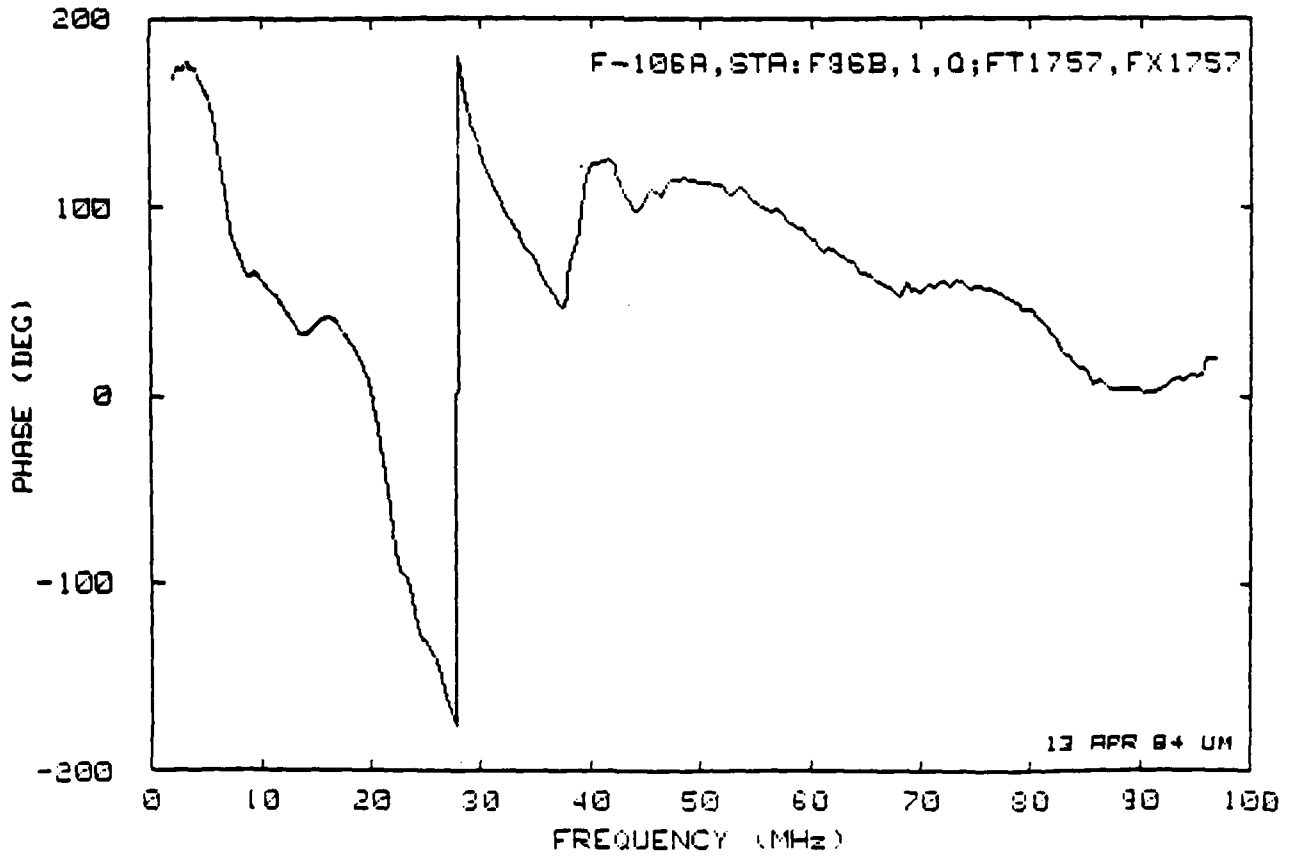
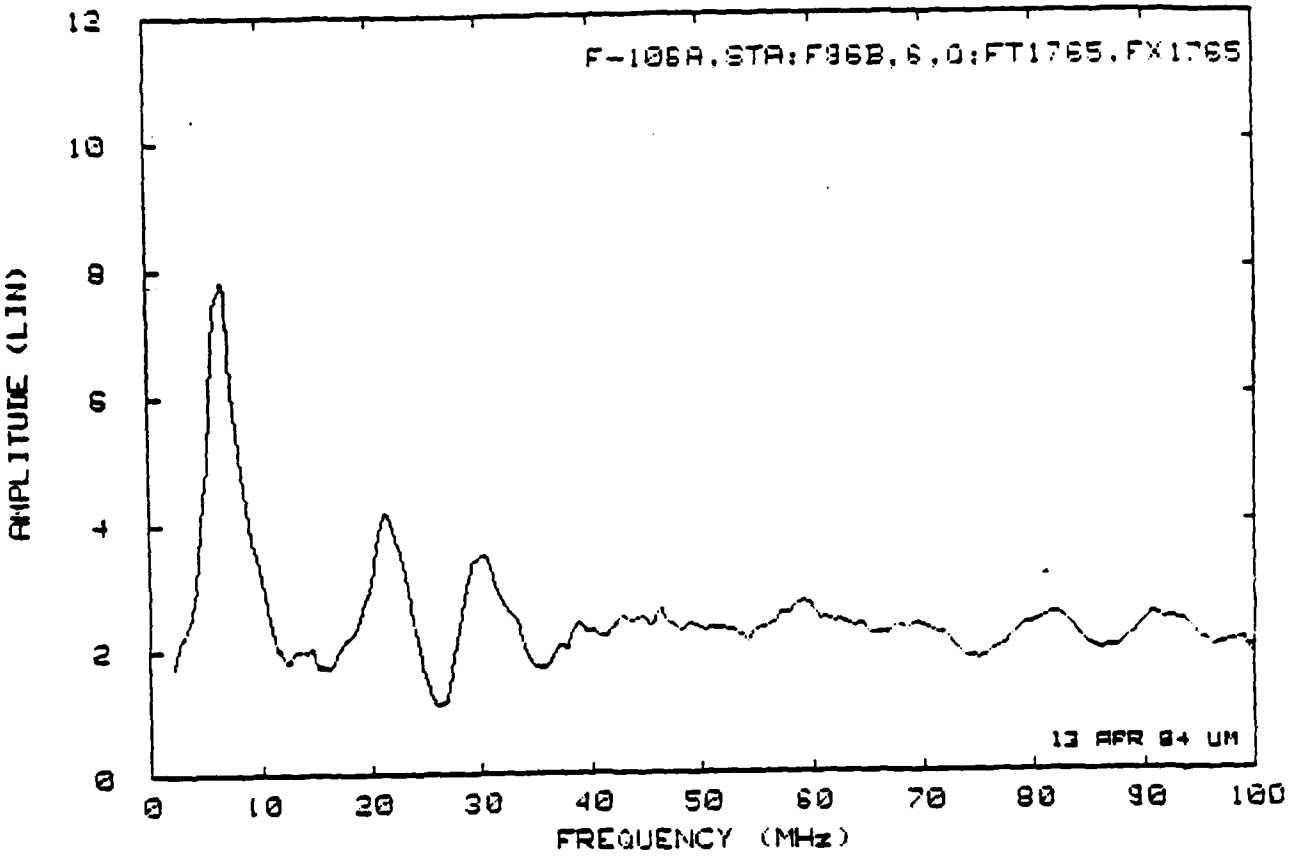
FREQUENCY (MHz)
13 APR 84 UM

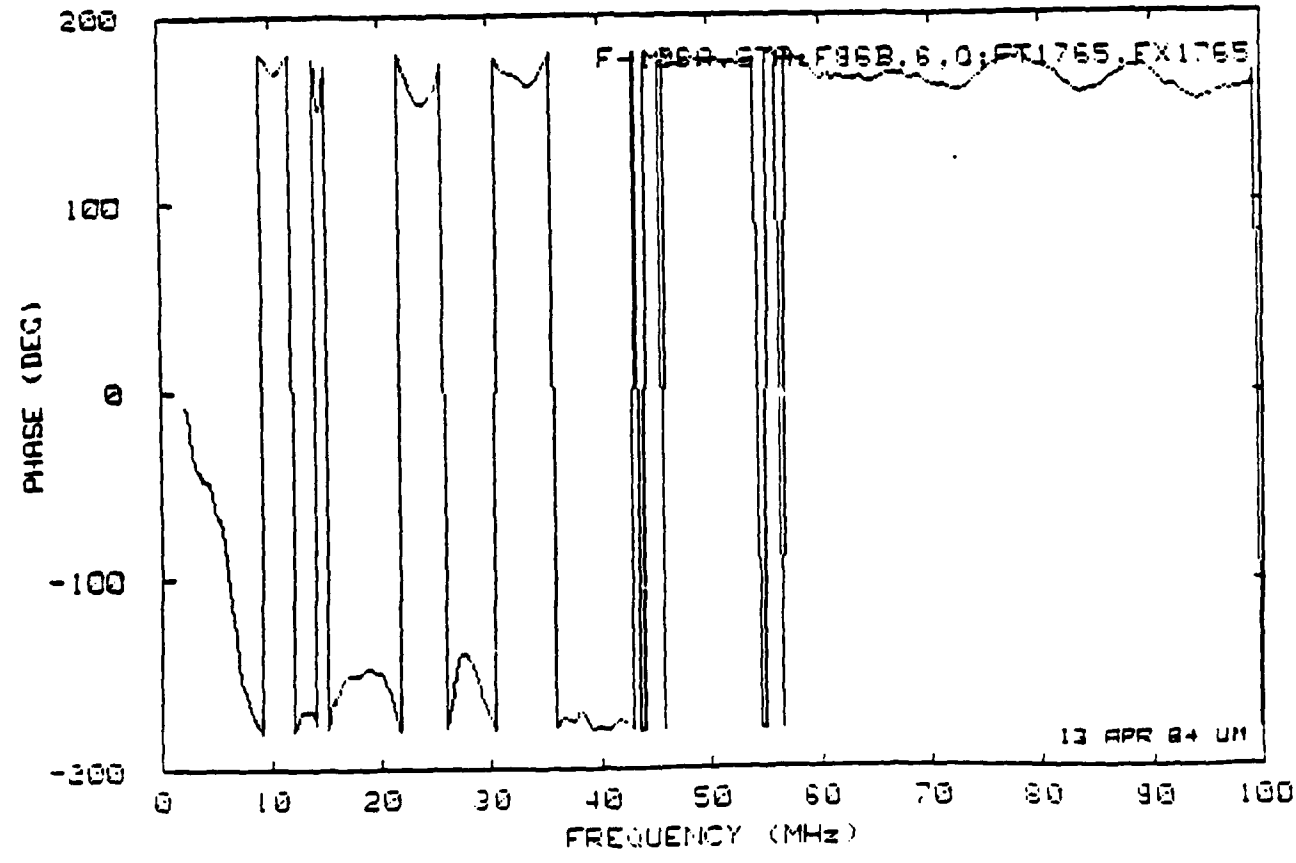

F-106A,STA:WL164B,1,Q;FT1617,FX1617
AMPLITUDE (LIN)
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM

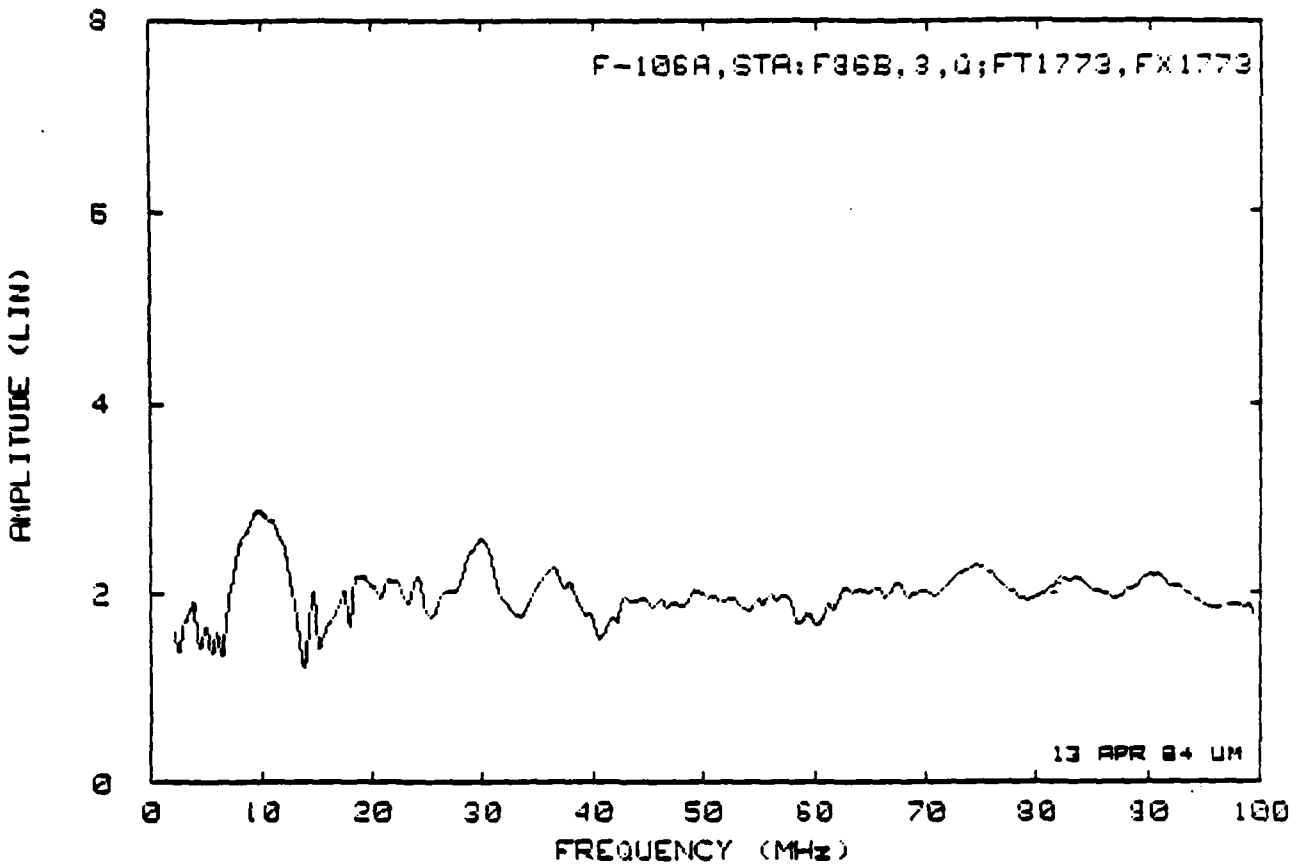

F-106A,STA:WL164B,1,Q;FT1617,FX1617
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM

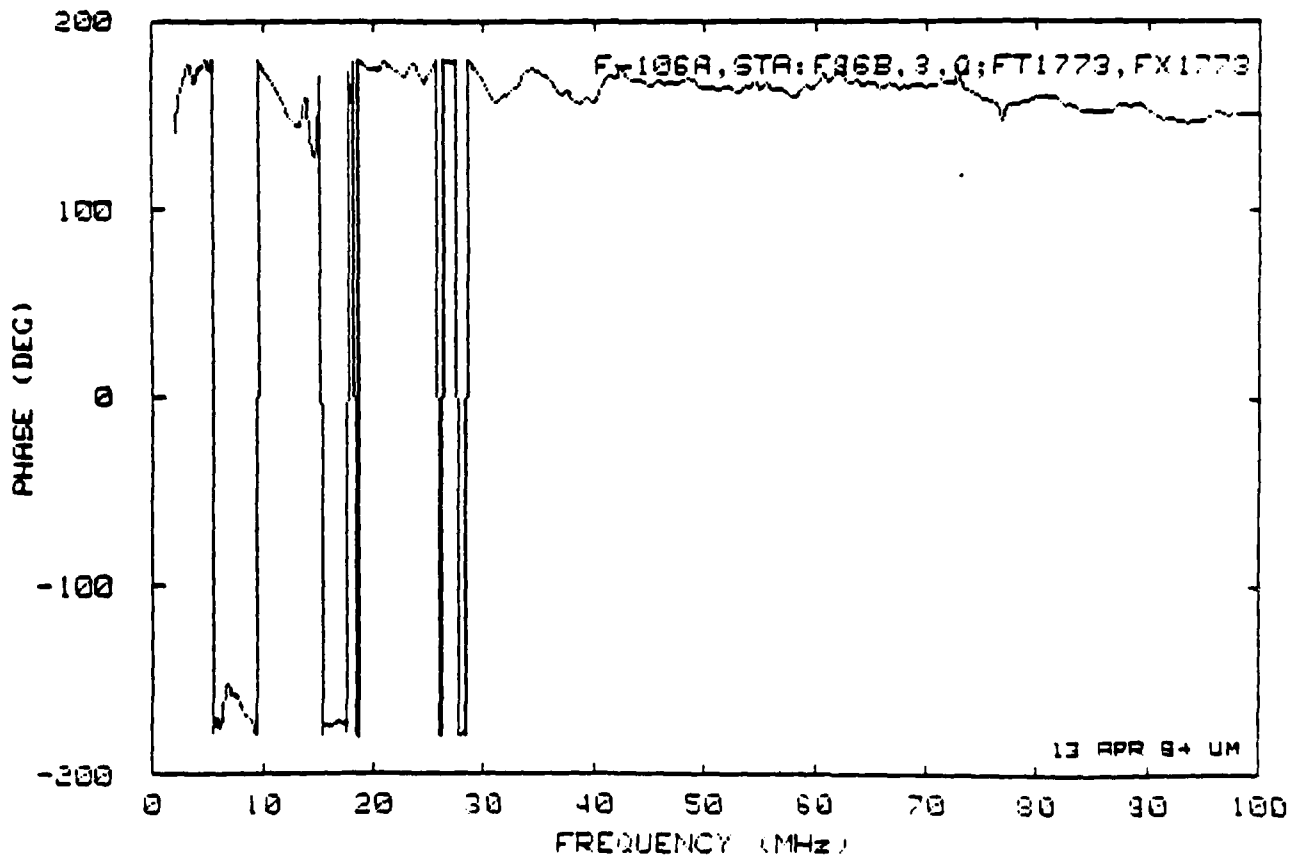

F-106A,STA:F96B,1,Q;FT1757,FX1757
AMPLITUDE (LIN)
20
16
12
8
4
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F96B,1,Q;FT1757,FX1757
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F86B,6,0:FT1765,FX1765
AMPLITUDE (LIN)
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F86B,6,0:FT1765,FX1765
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F86B,3,0;FT1773,FX1773
AMPLITUDE (LIN)
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F86B,3,0;FT1773,FX1773
PHASE (DEG)
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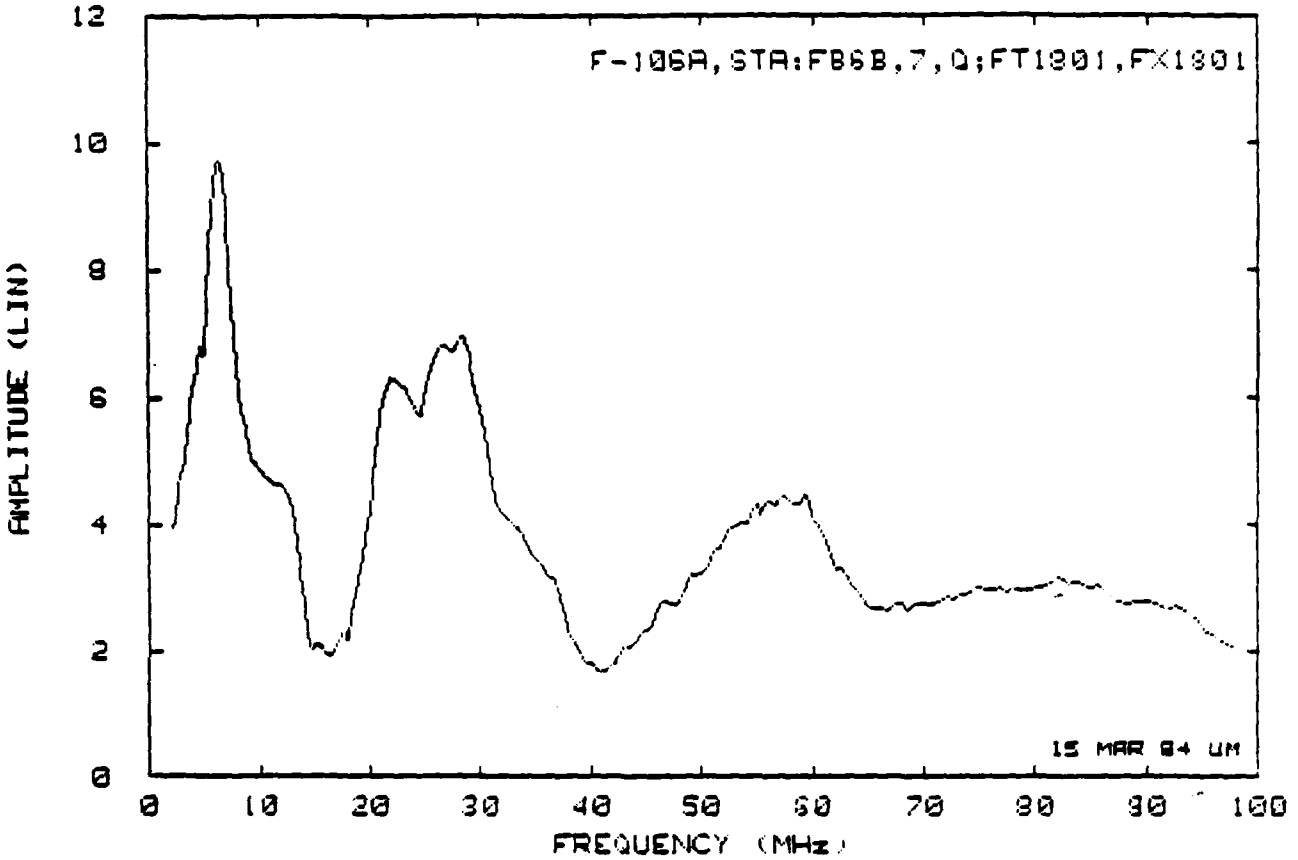
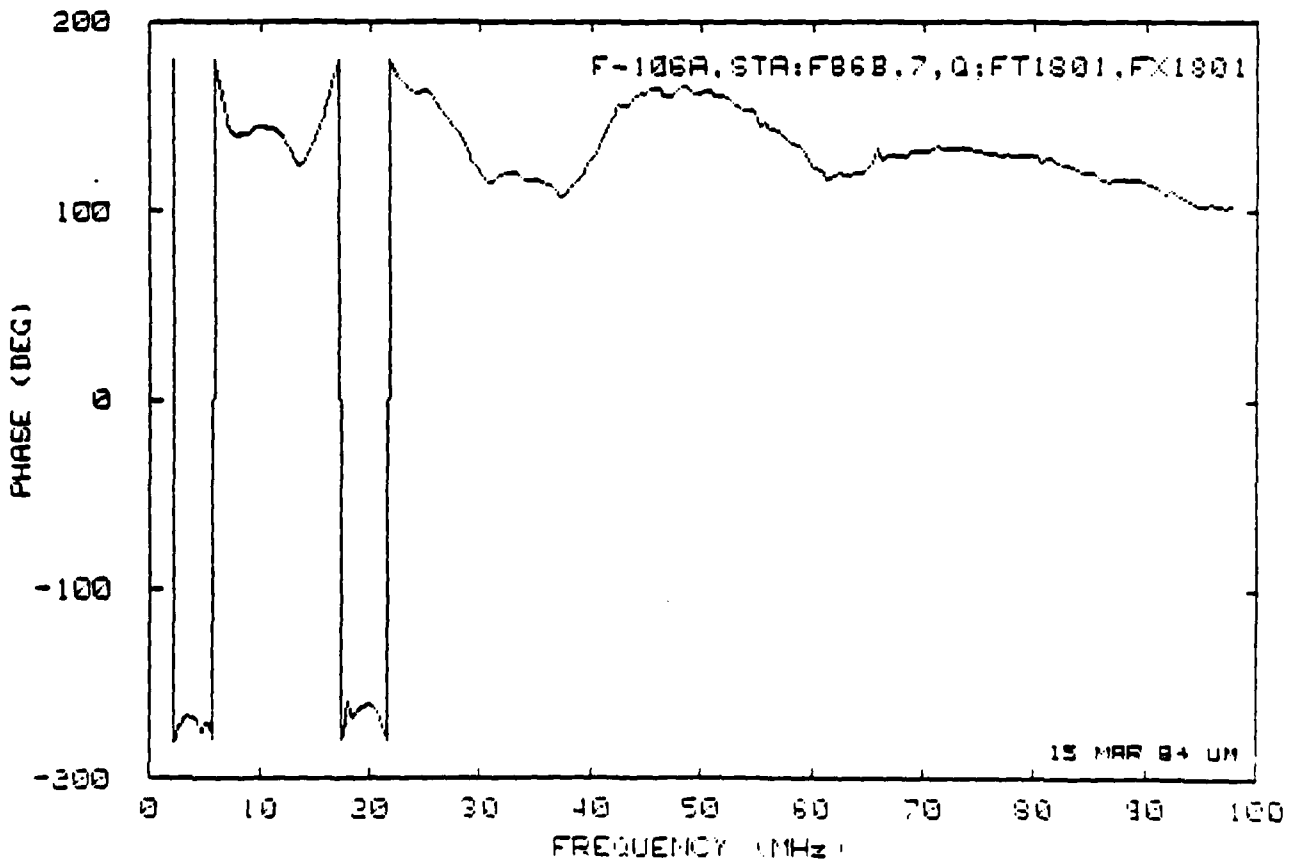
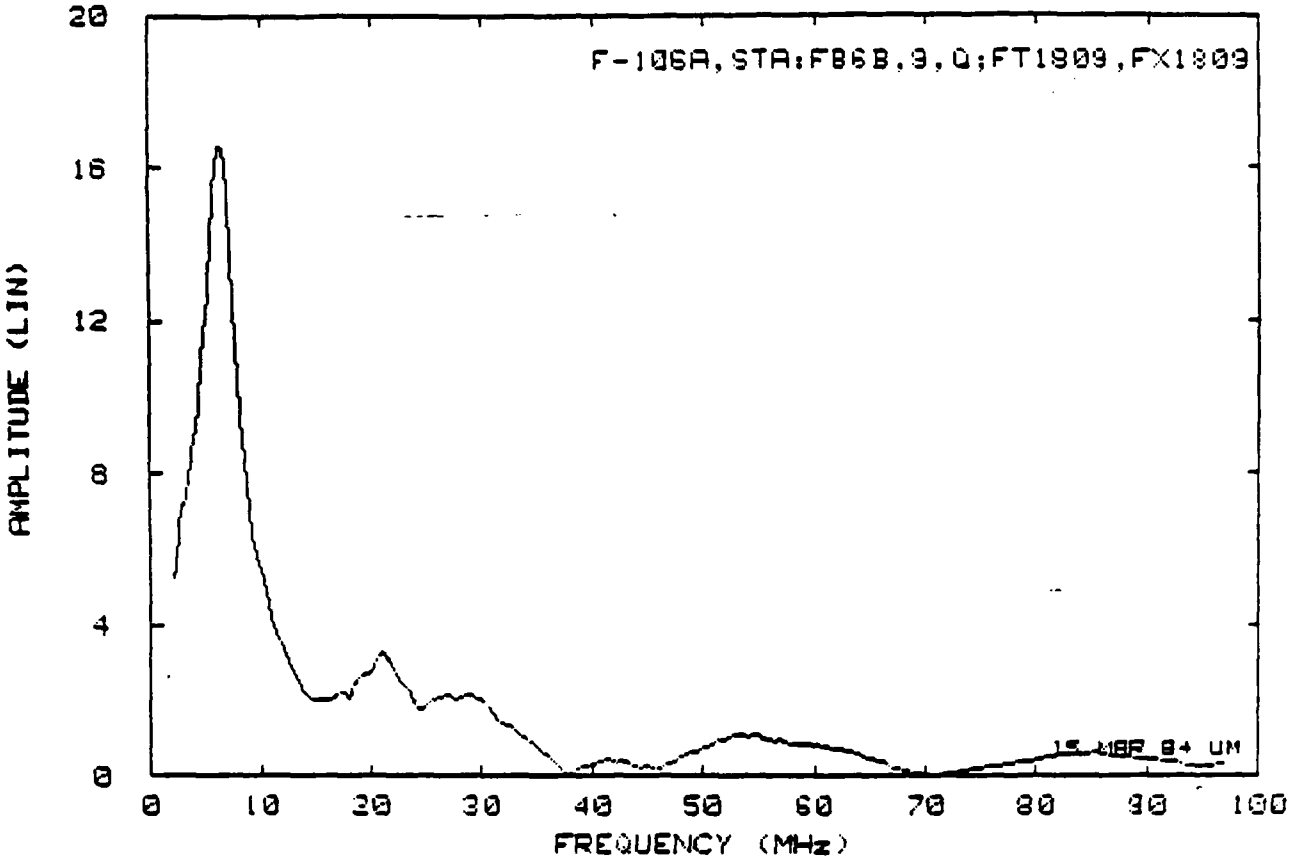
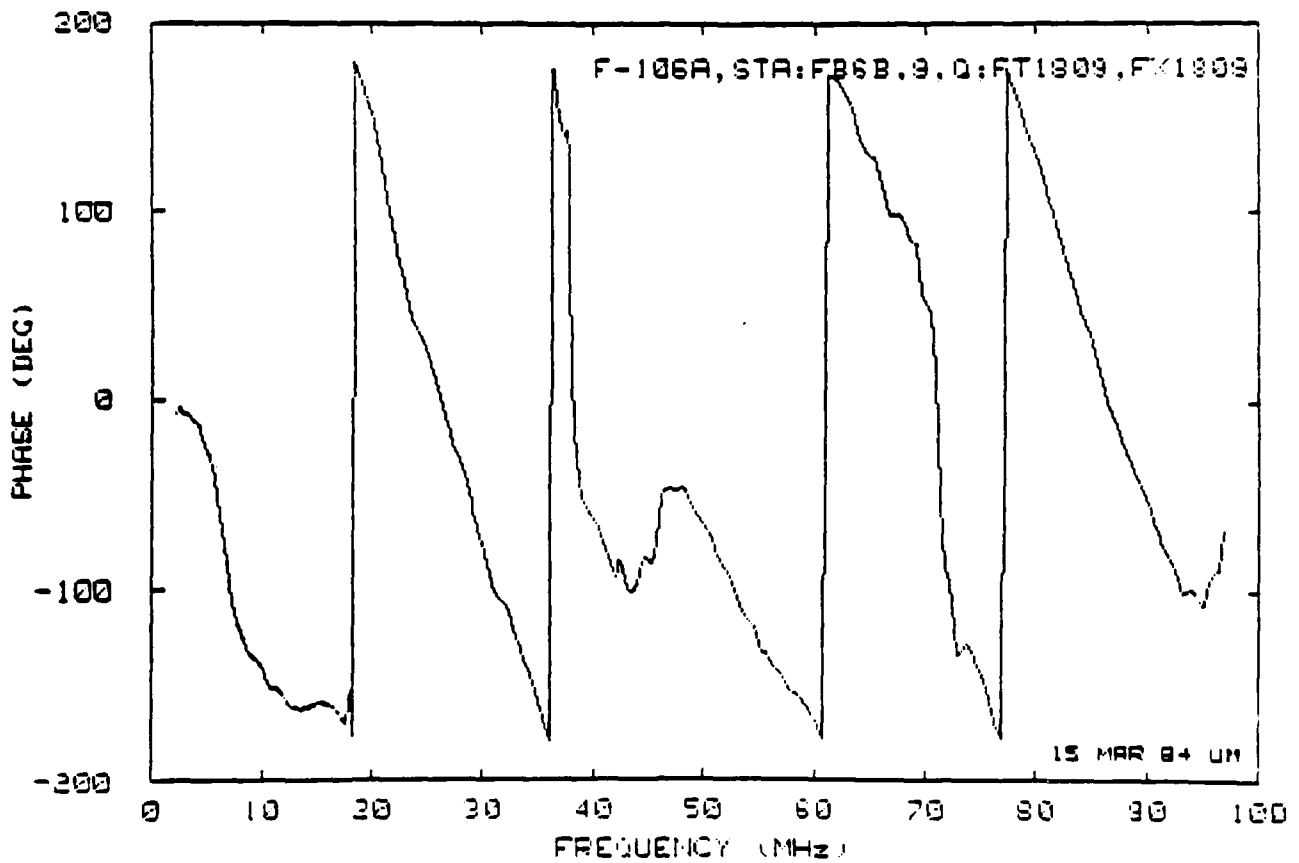
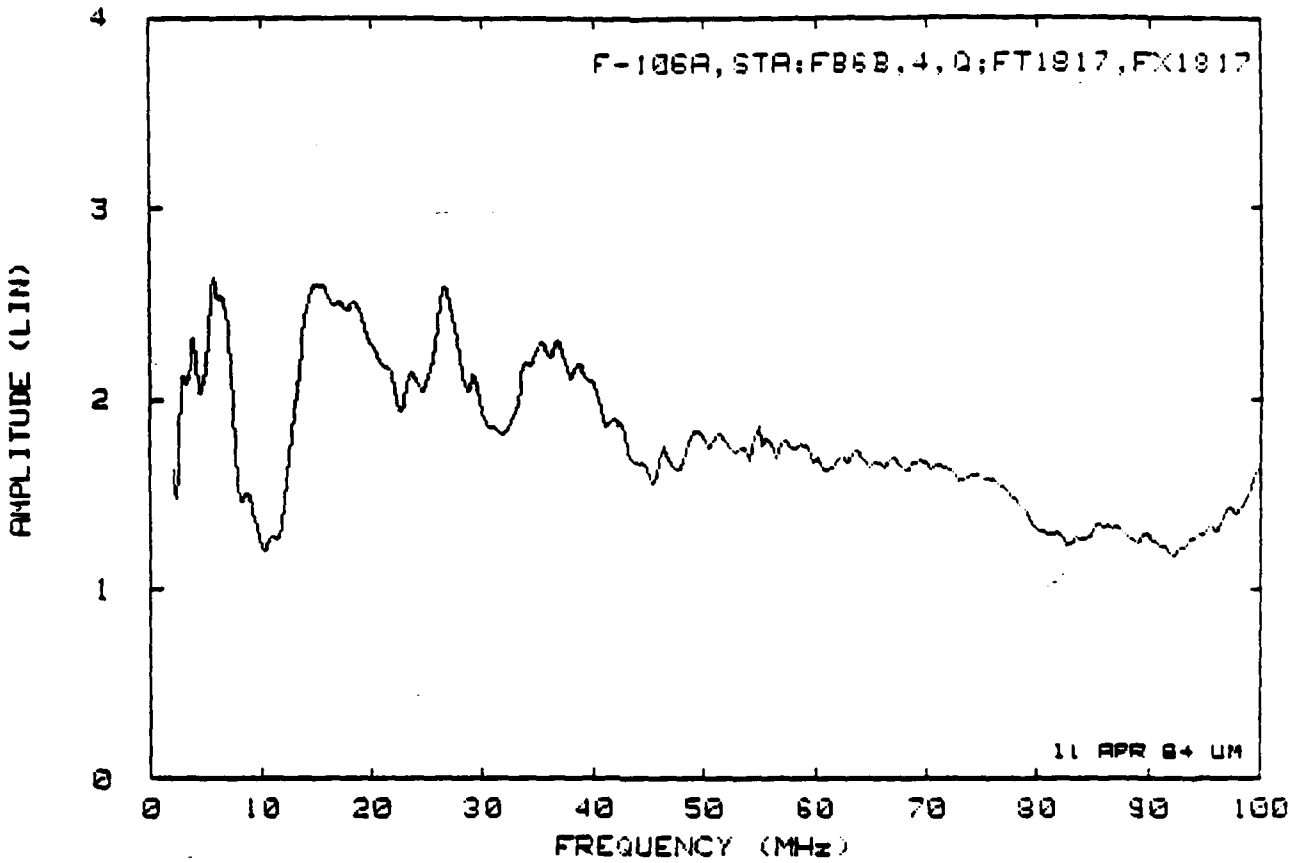
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM

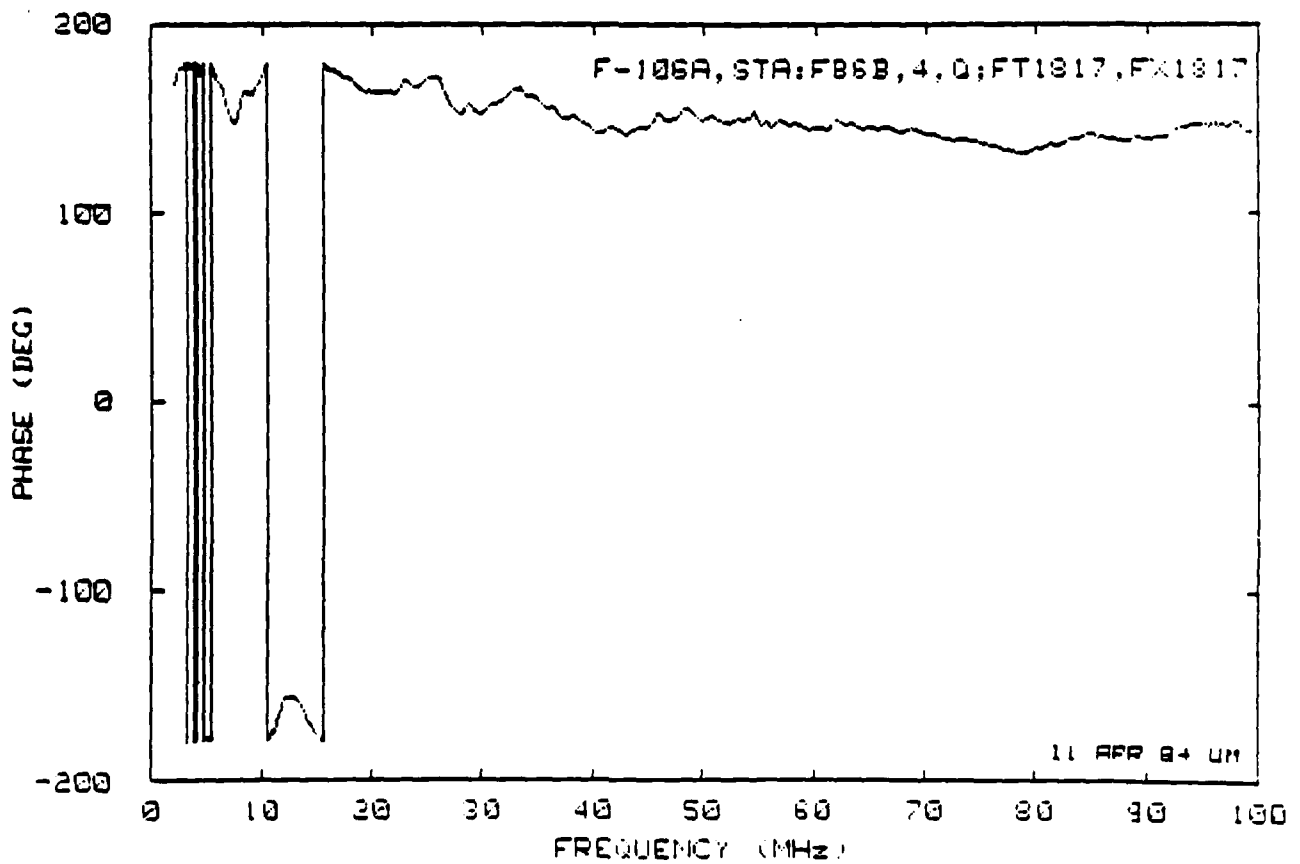

F-106A,STA:FB6B,7,Q;FT1801,FX1801
AMPLITUDE (LIN)
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM

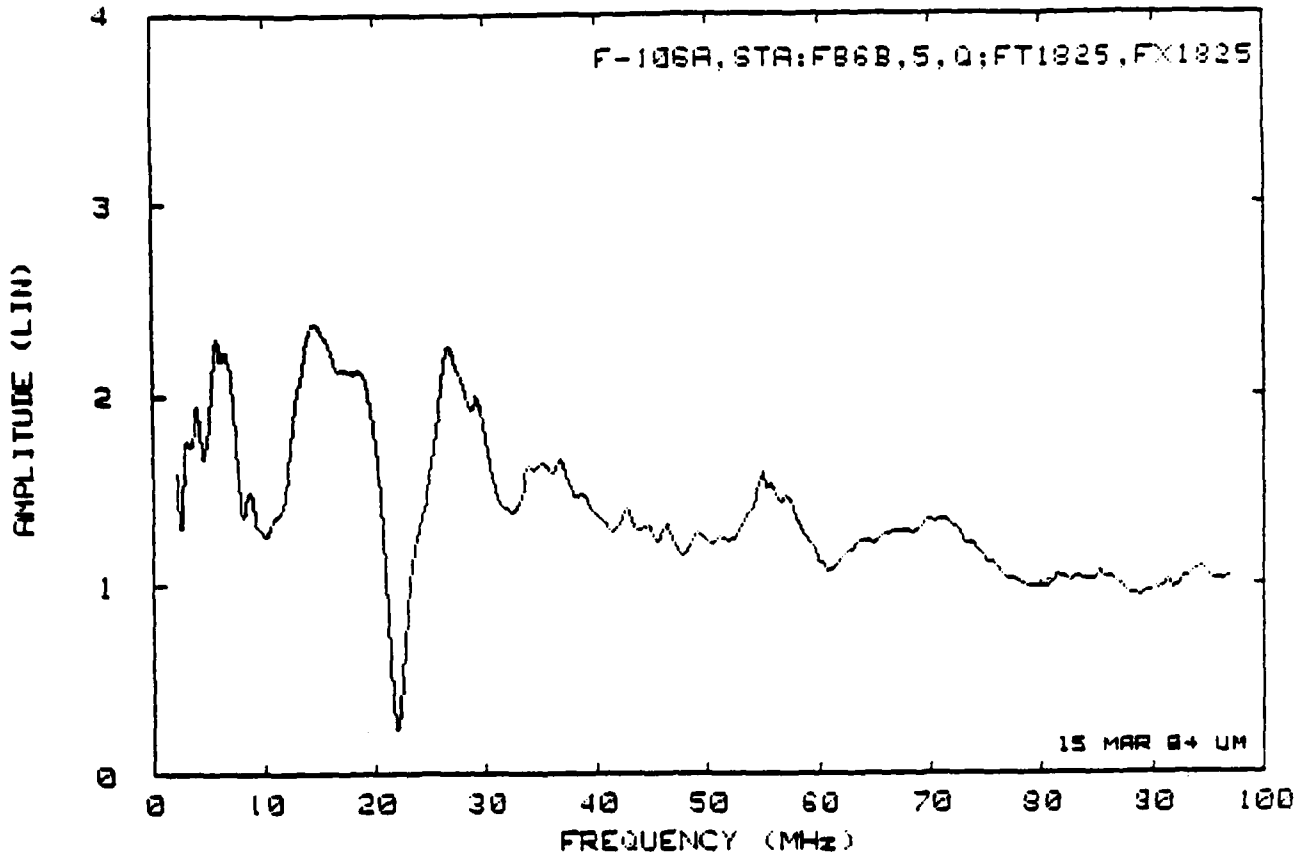

F-106A,STA:FB6B,7,Q;FT1801,FX1801
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM

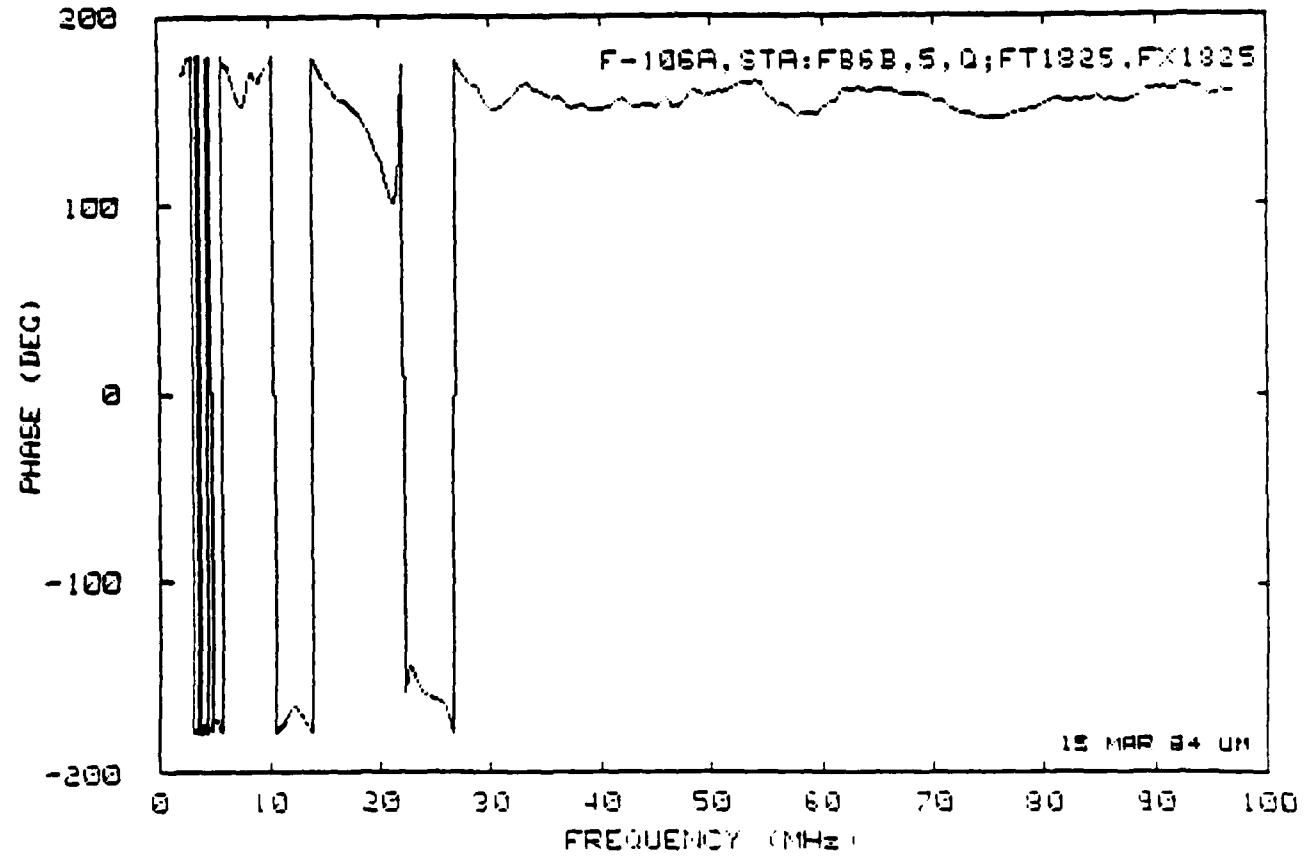

F-106A, STA:FB6B, 9, Q; FT1809, FX1809
AMPLITUDE (LIN)
20
16
12
8
4
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A, STA:FB6B, 9, Q; FT1809, FX1809
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A, STA:FB6B,4,Q;FT1817,FX1817
AMPLITUDE (LIN)
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
11 APR 84 UM


F-106A, STA:FB6B,4,Q;FT1817,FX1817
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
11 APR 84 UM


F-106A, STA:FB6B,5,Q;FT1825,FX1825
AMPLITUDE (LIN)
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A, STA:FB6B,5,Q;FT1825,FX1825
PHASE (DEG)
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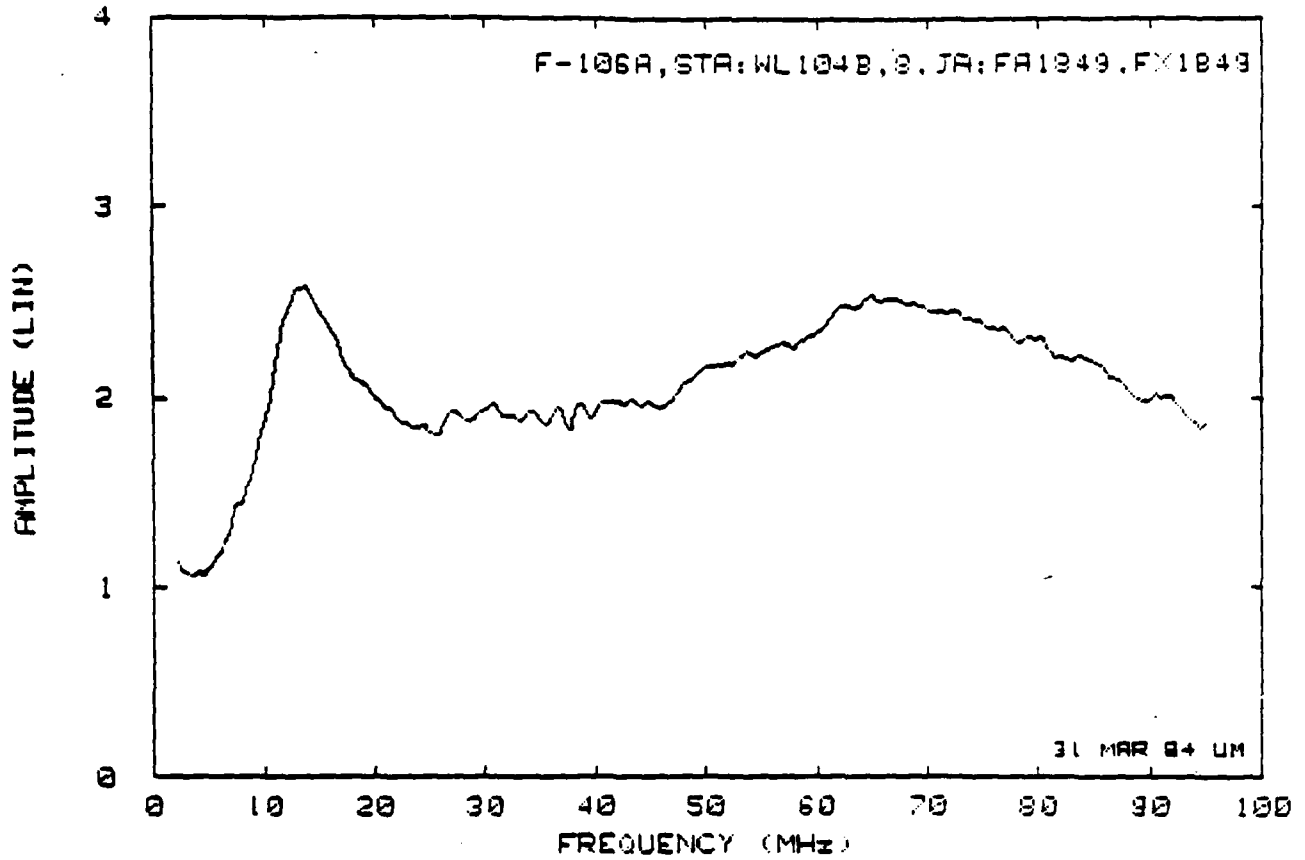
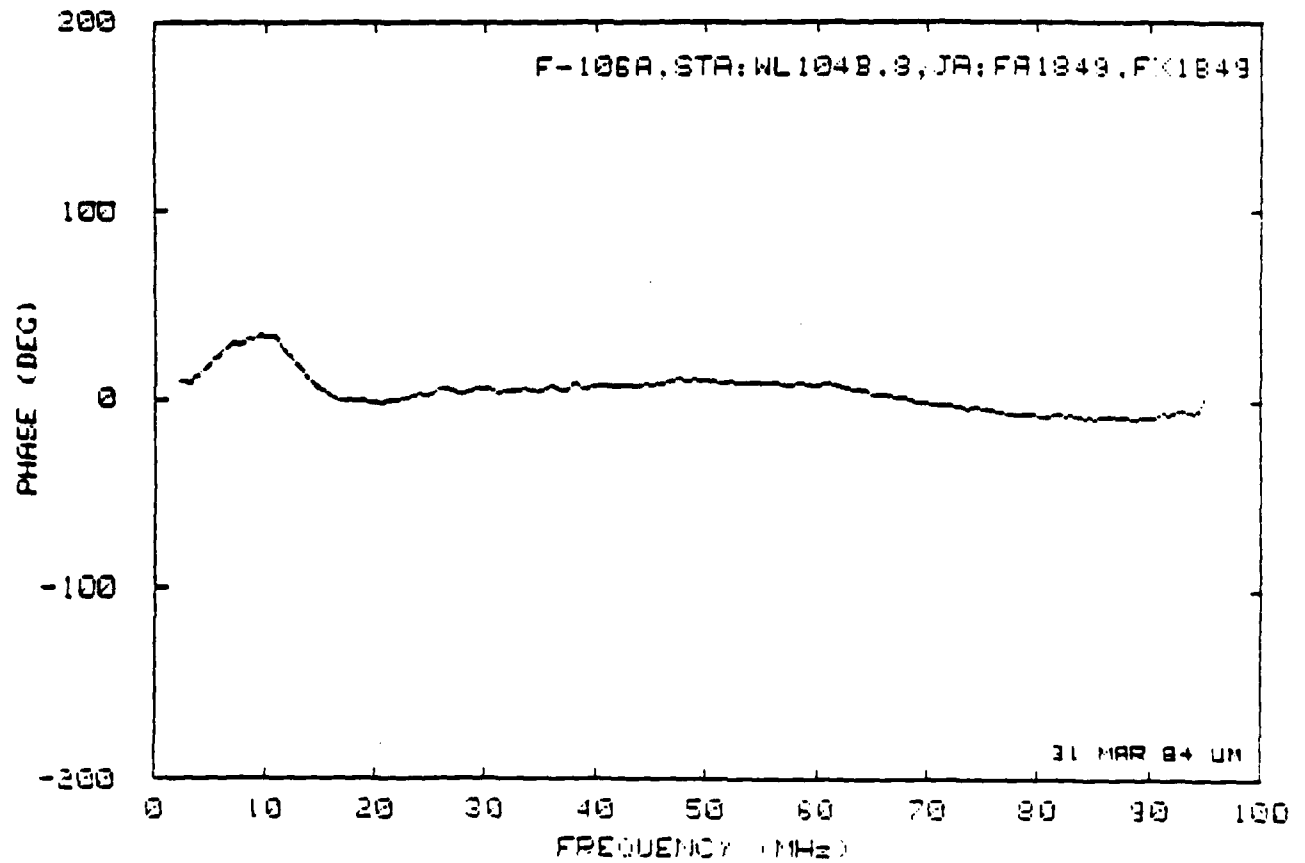
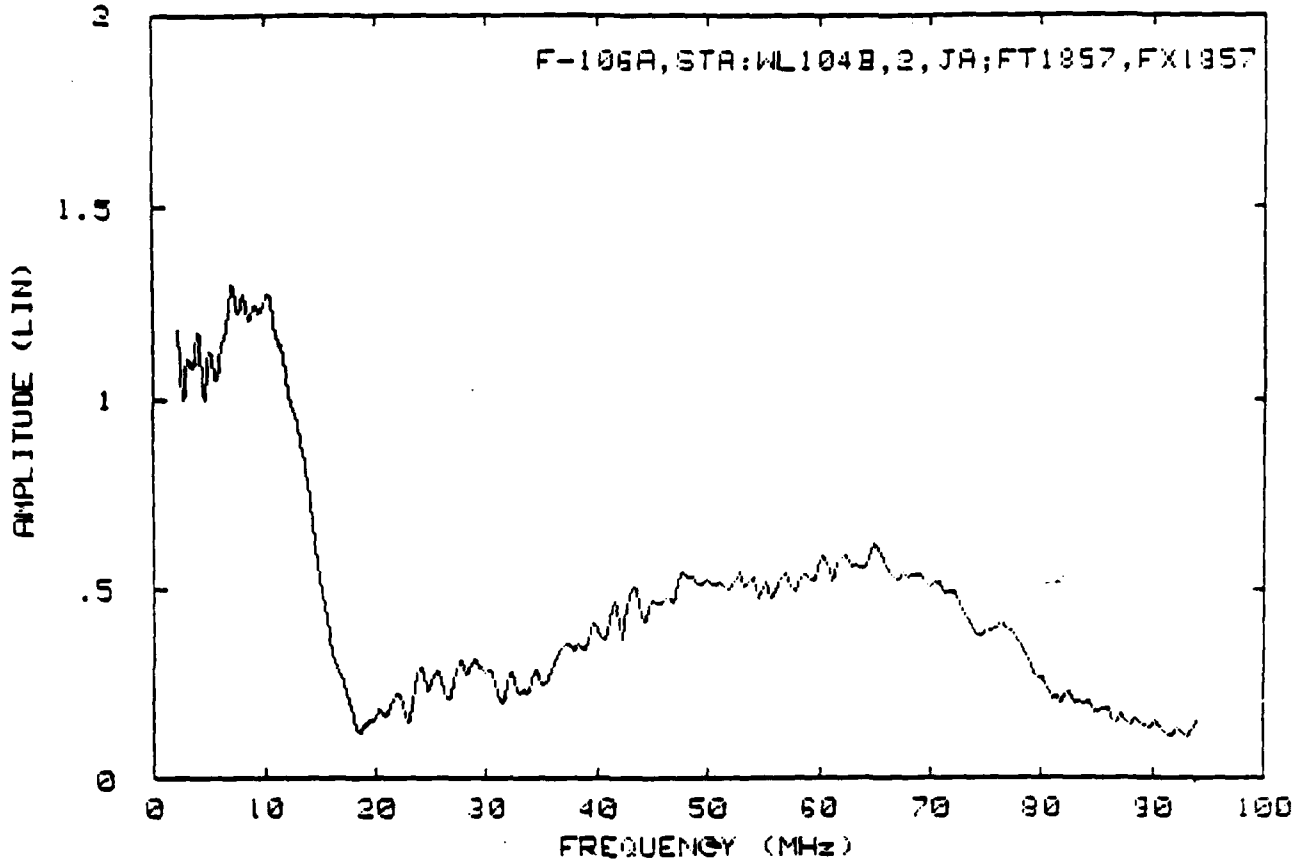
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,3,JA:FA1849,FX1849
AMPLITUDE (LIN)
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
31 MAR 84 UM


F-106A,STA:WL104B,3,JA:FA1849,FX1849
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
31 MAR 84 UM


F-106A,STA:WL1048,2,JA;FT1857,FX1857
AMPLITUDE (LIN)
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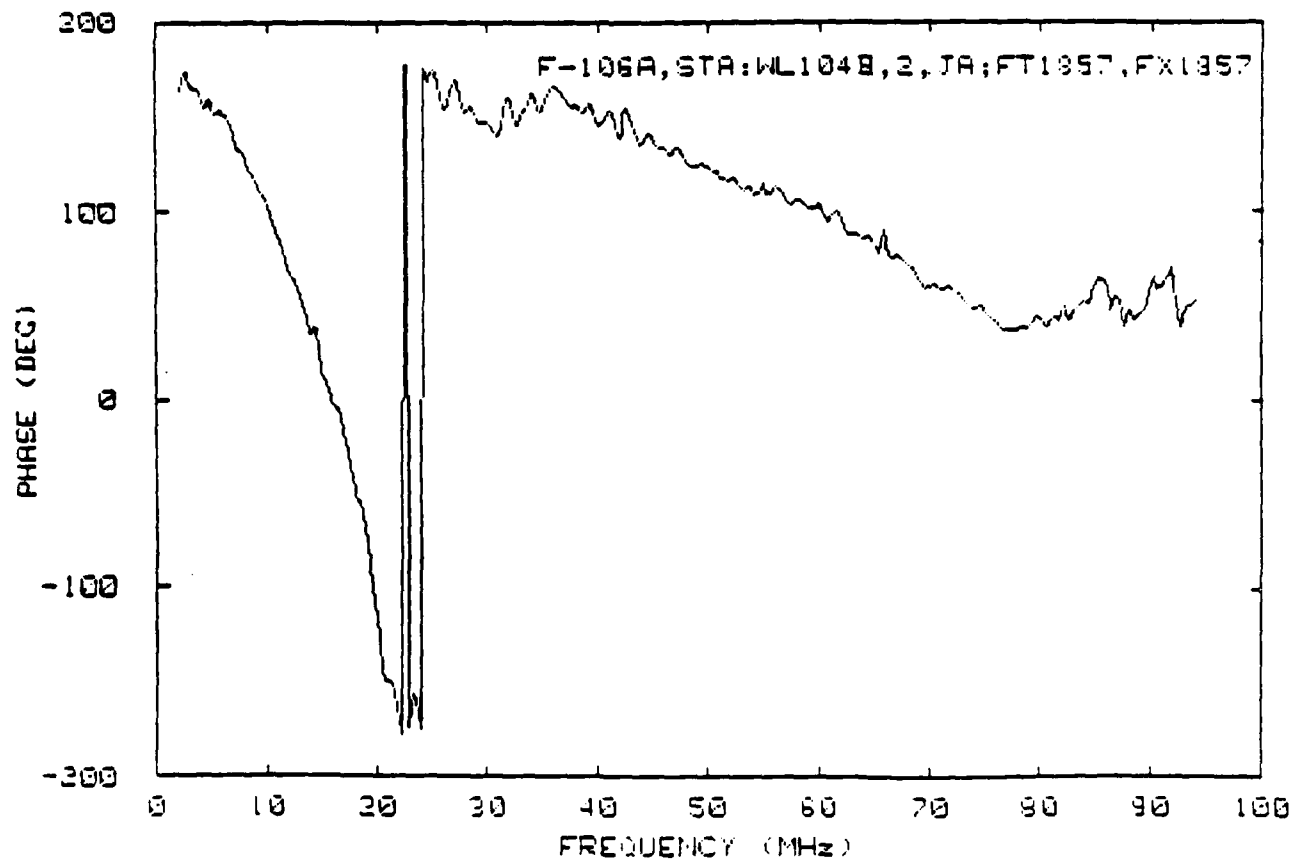
1.5
1
.5
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL1048,2,JA;FT1857,FX1857
PHASE (DEG)
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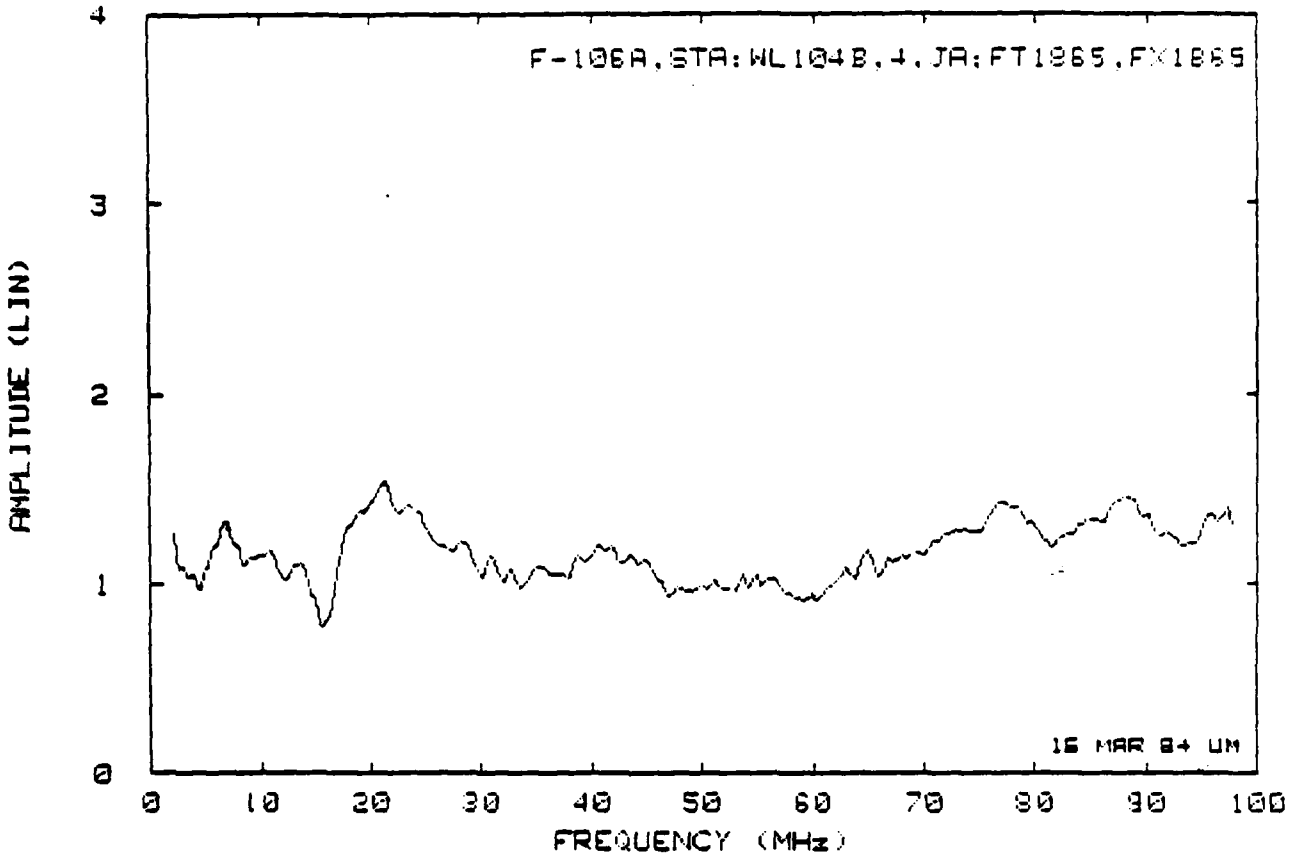
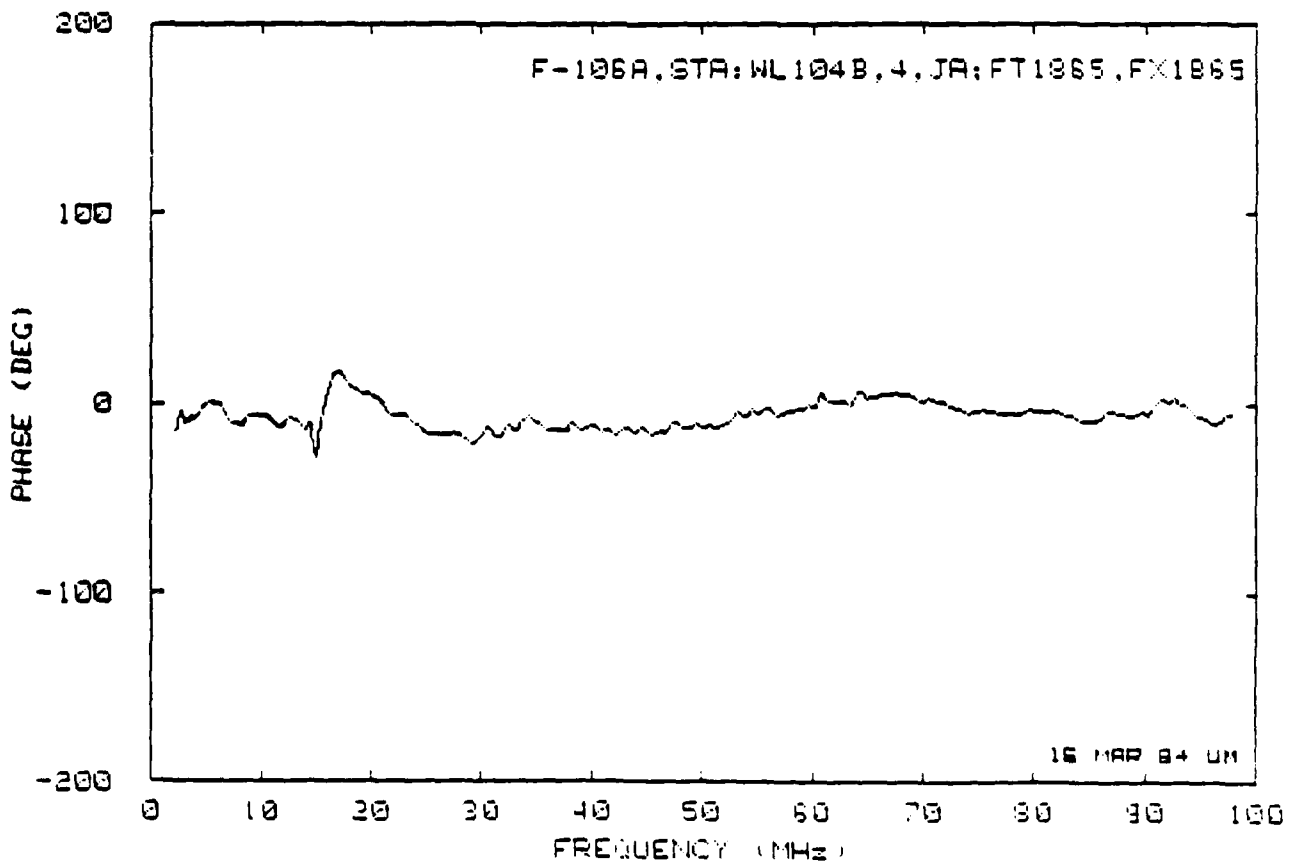
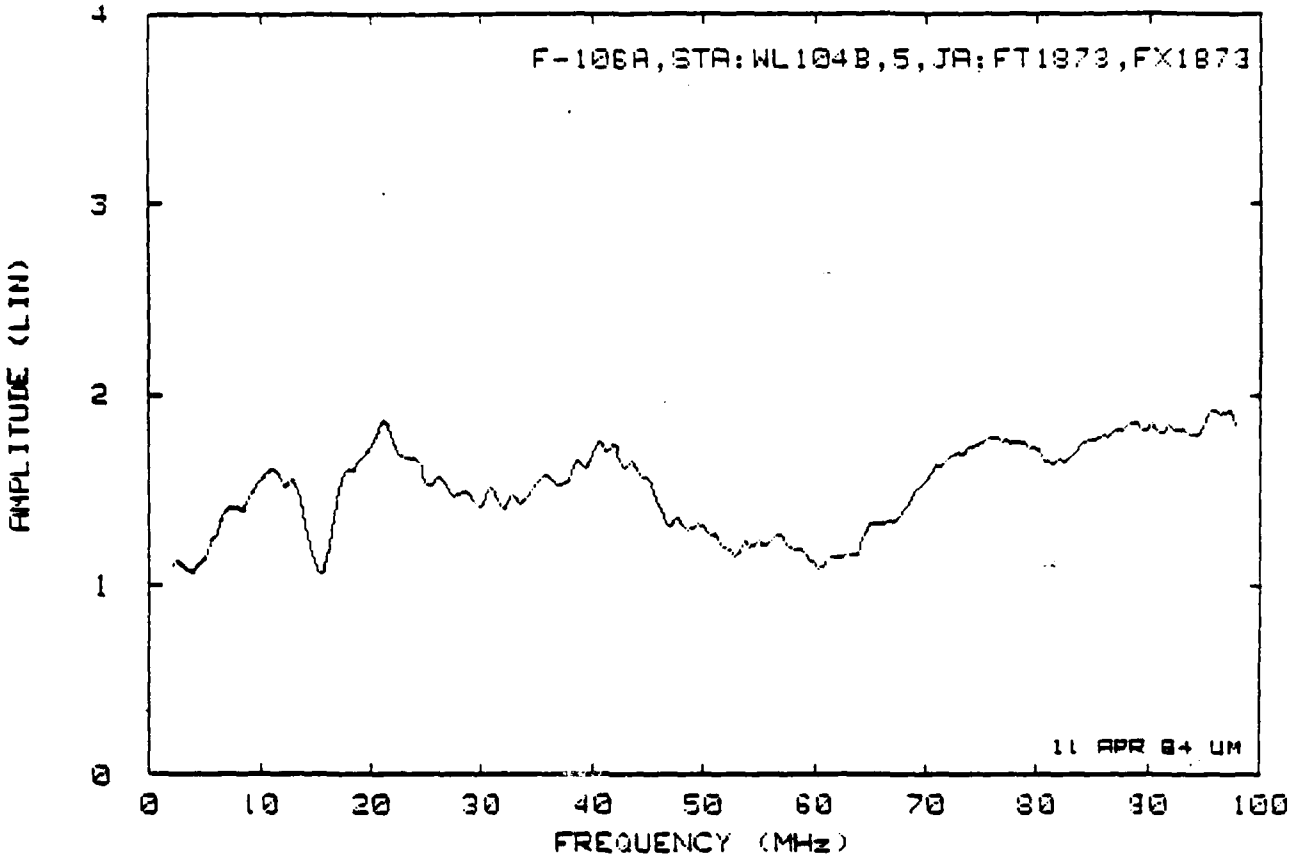
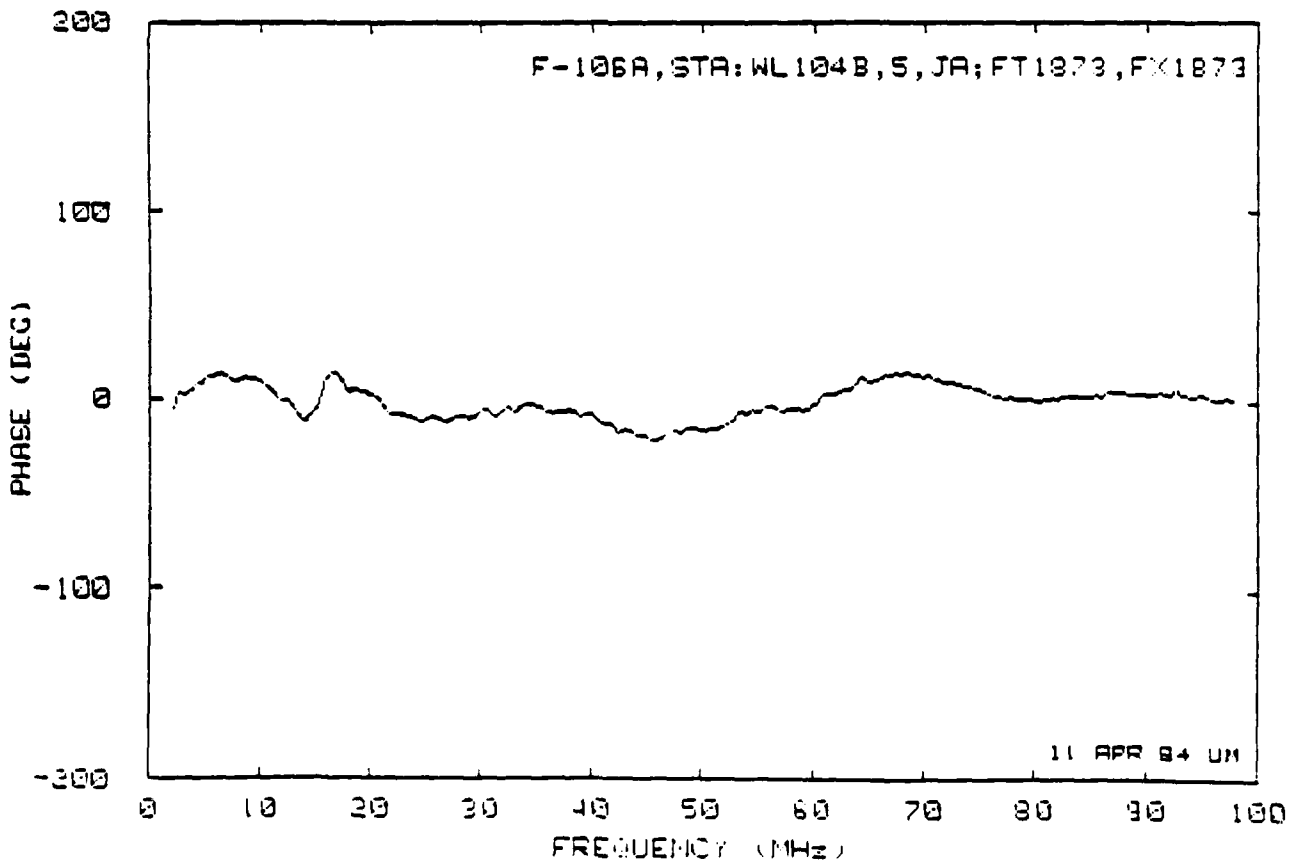
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL104B,4,JA:FT1865,FX1865
AMPLITUDE (LIN)
4
3
2
1
0
16 MAR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL104B,4,JA:FT1865,FX1865
PHASE (DEG)
200
100
0
-100
-200
16 MAR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL104B,5,JA;FT1873,FX1873
AMPLITUDE (LIN)
4
3
2
1
0
11 APR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL104B,5,JA;FT1873,FX1873
PHASE (DEG)
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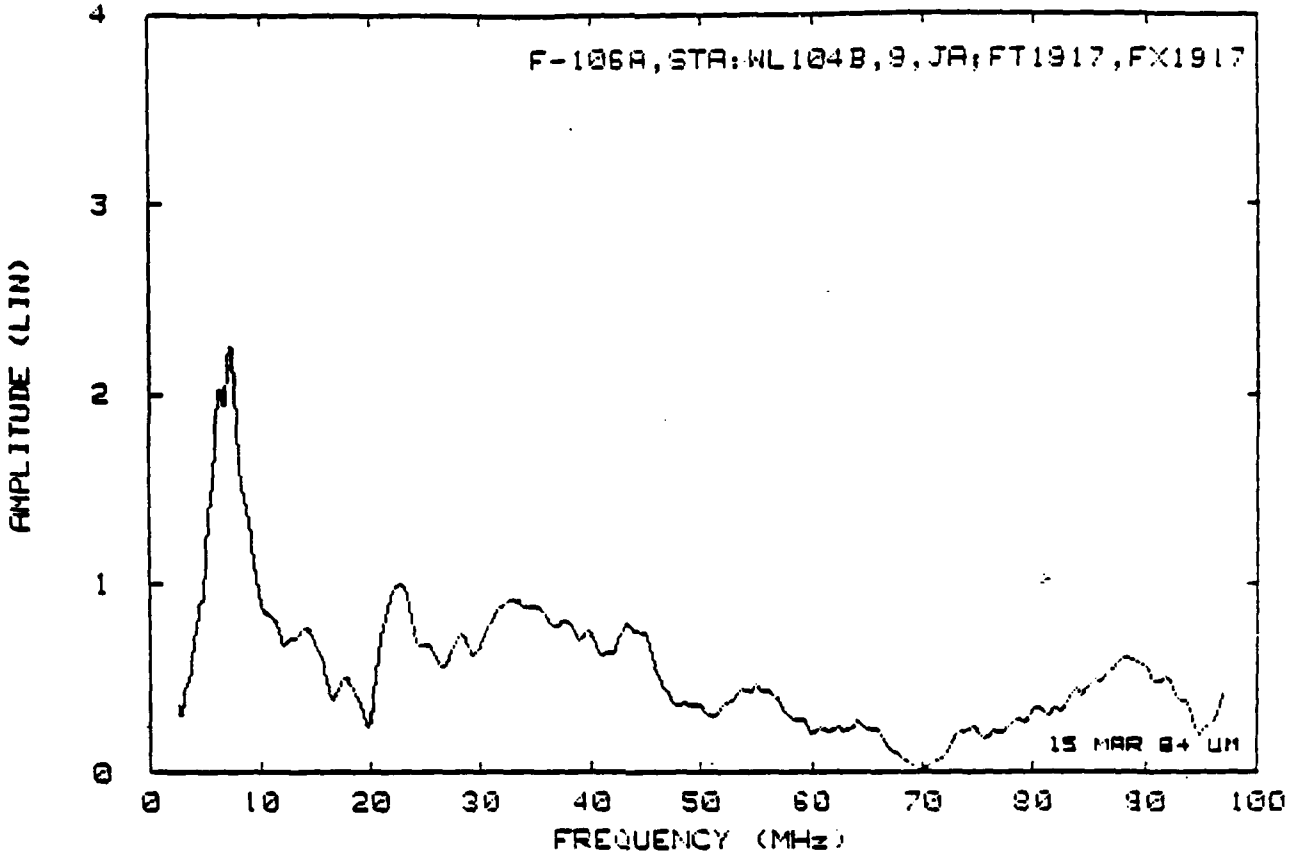
100
0
-100
-200
11 APR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL104B,9,JA;FT1917,FX1917
AMPLITUDE (LIN)
4
3
2
1
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0
10
20
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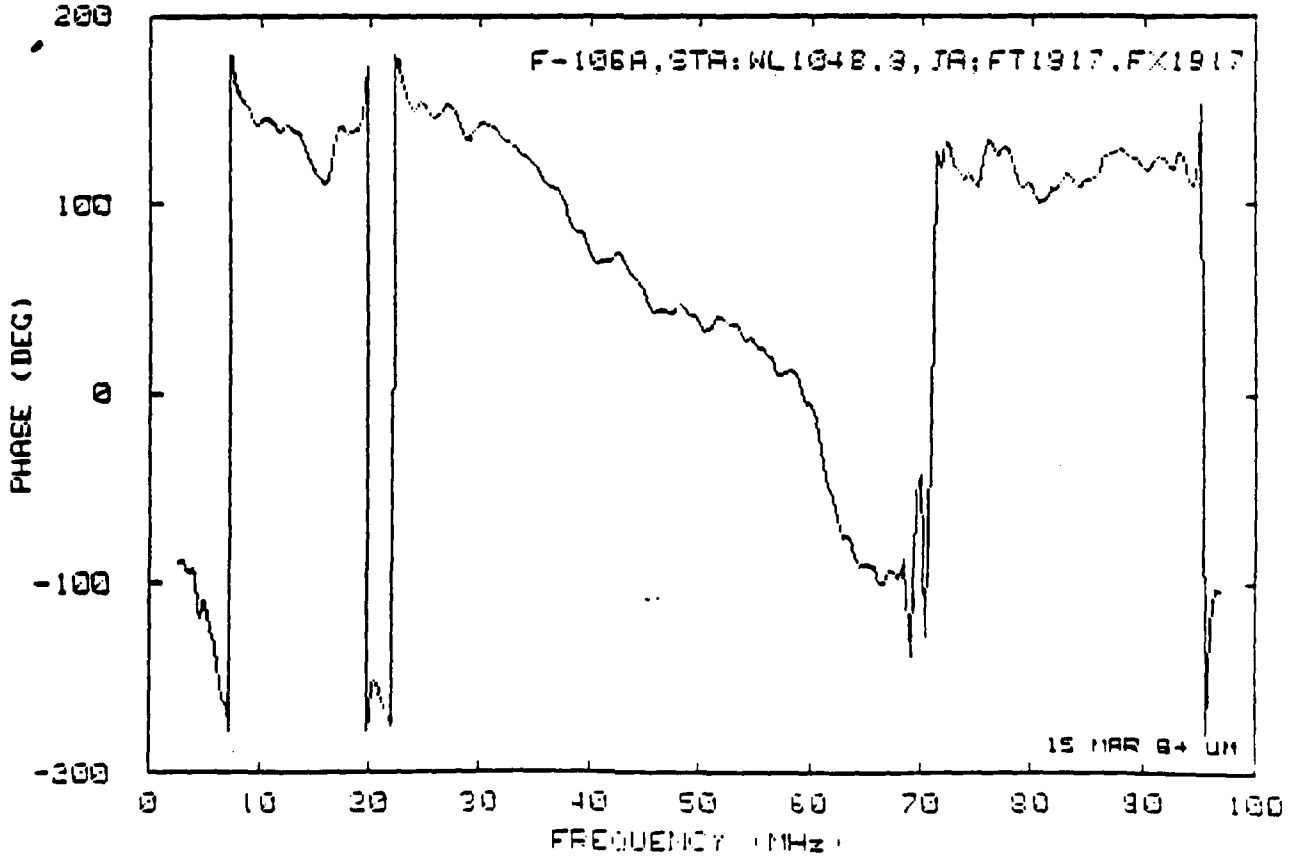
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,9,JA;FT1917,FX1917
PHASE (DEG)
200
100
0
-100
-200
0
10
20
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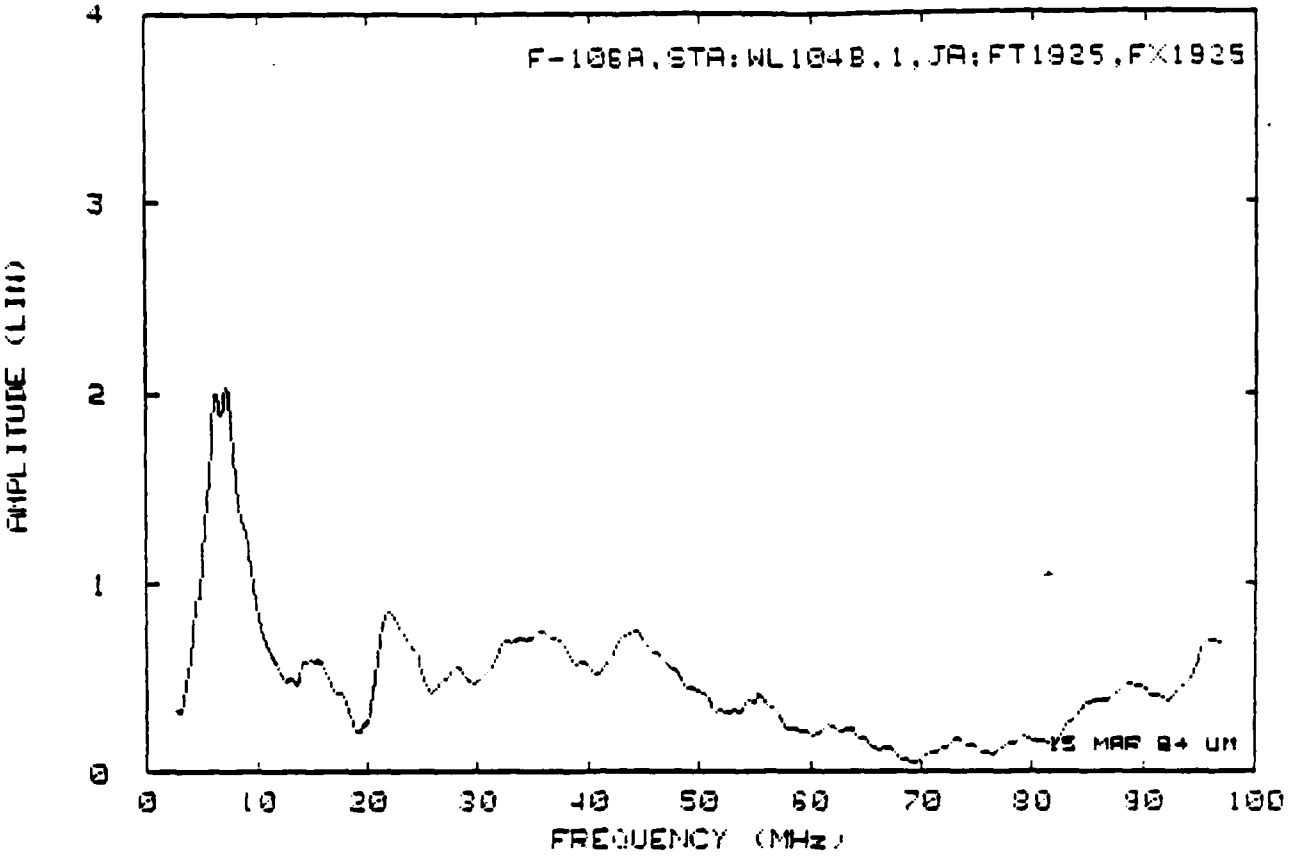
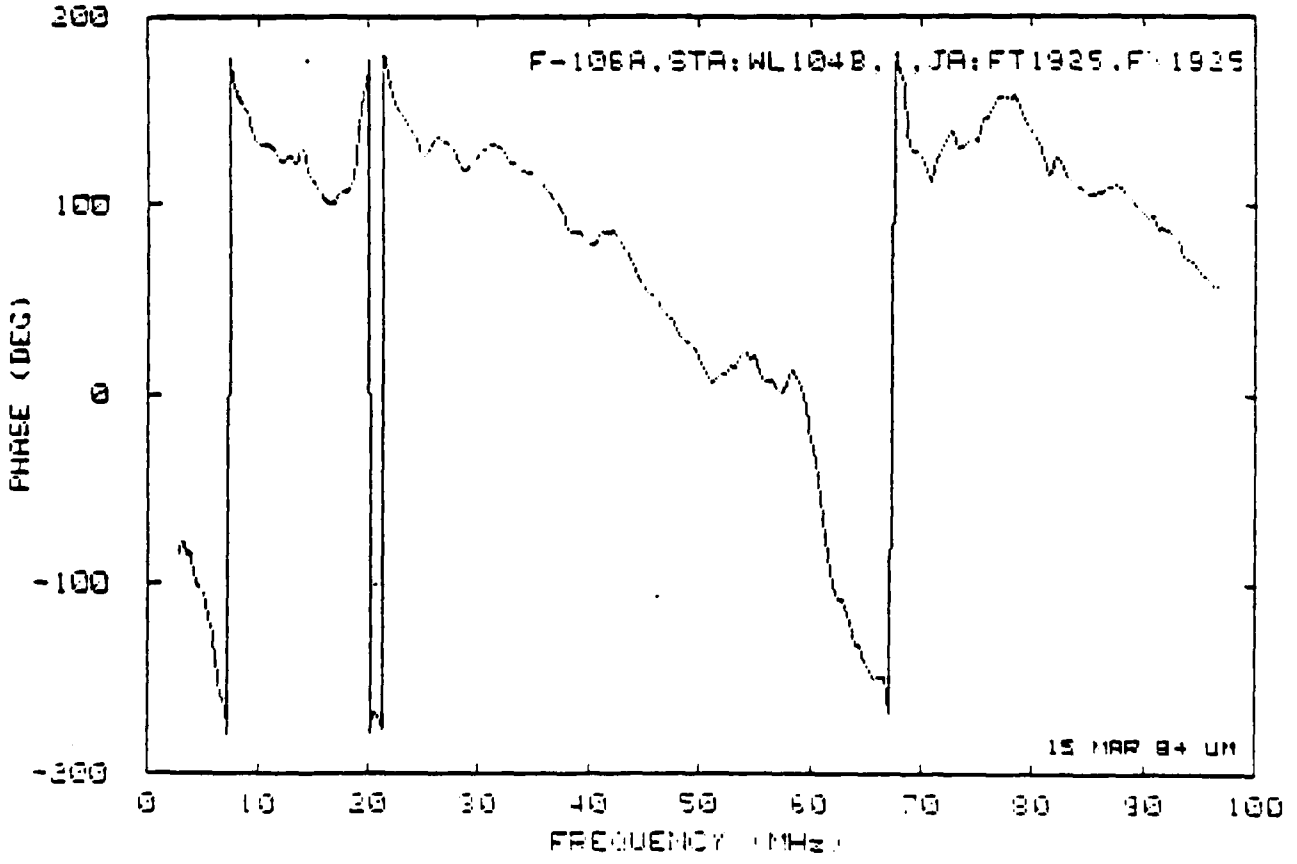
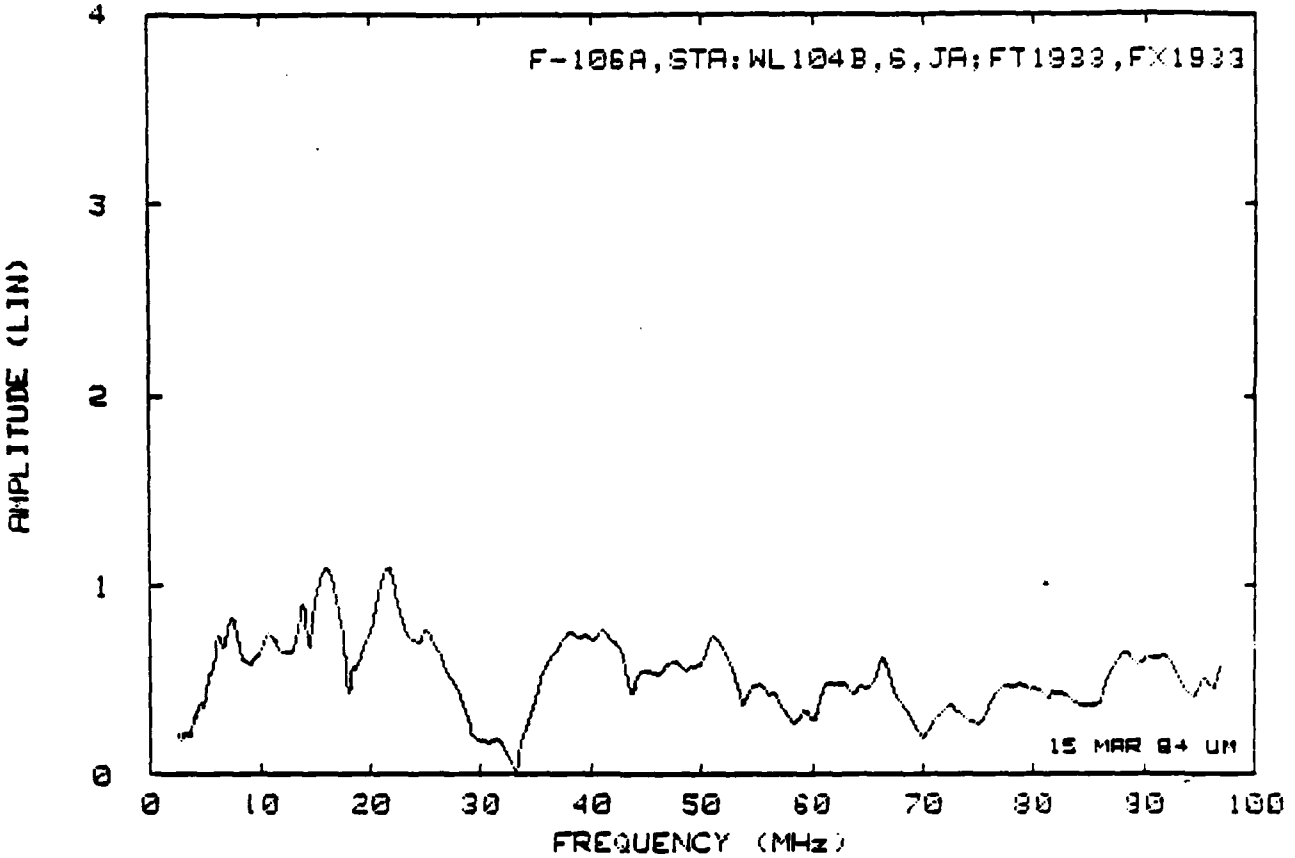
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B.1,JA:FT1925,FX1925
AMPLITUDE (LIN)
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B.1,JA:FT1925,FX1925
PHASE (DEG)
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,6,JA;FT1933,FX1933
AMPLITUDE (LIN)
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1
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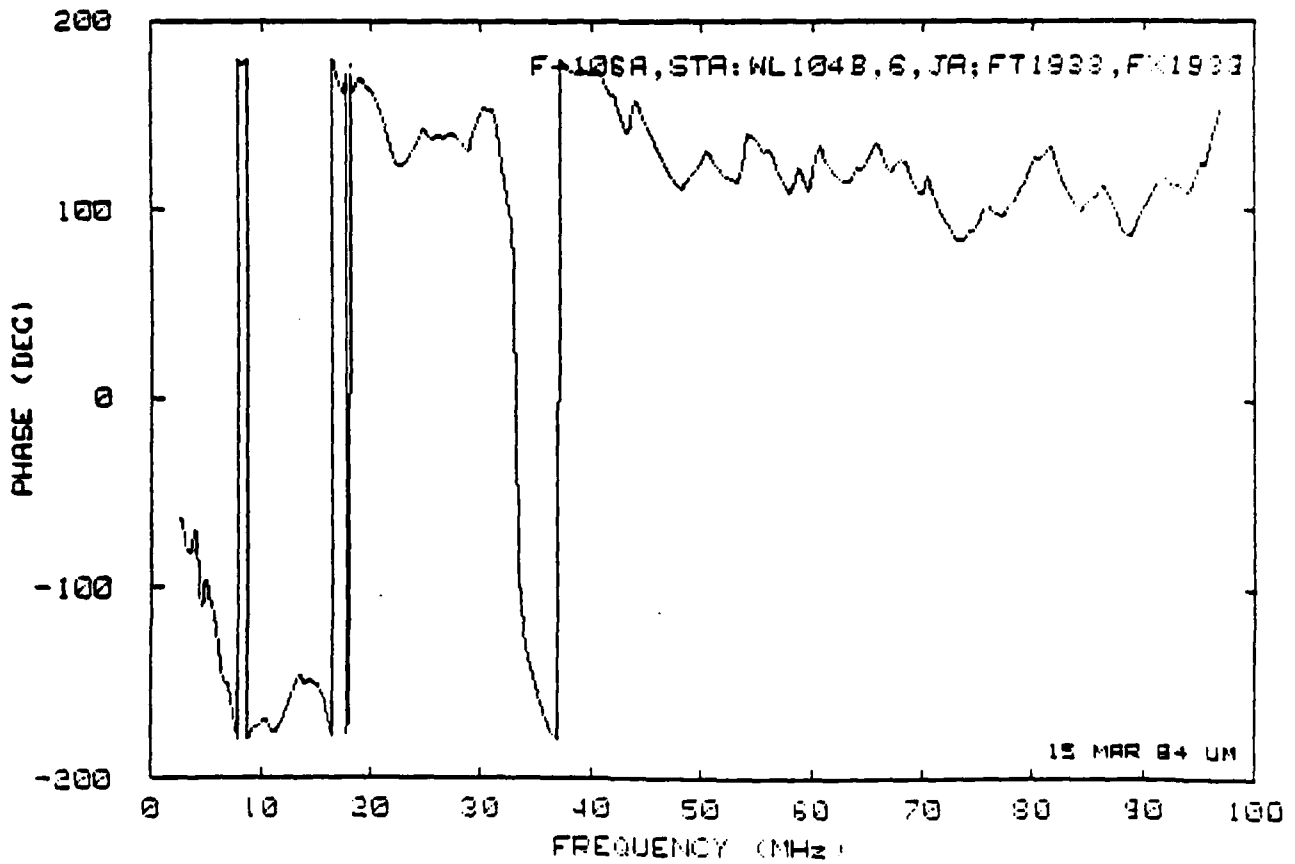
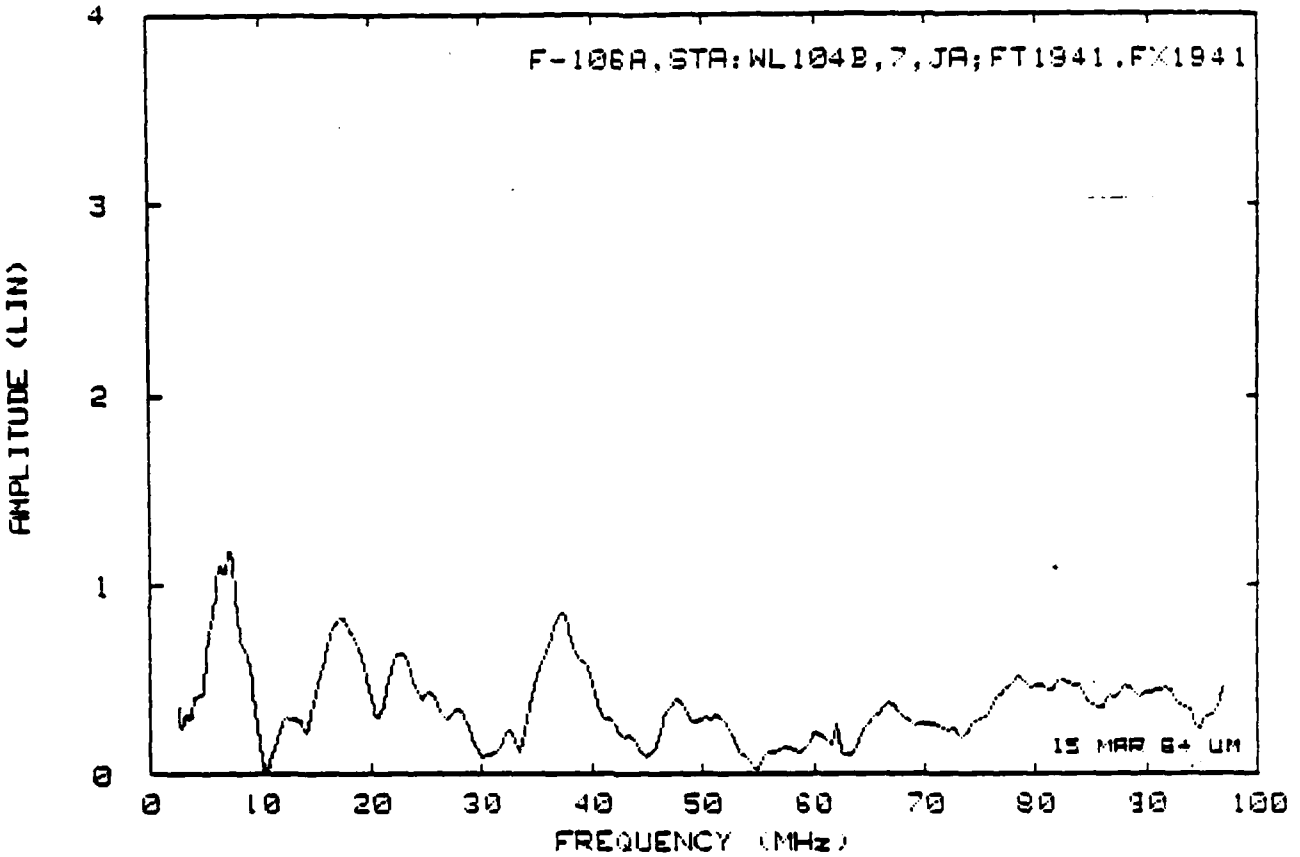
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,6,JA;FT1933,FX1933
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,7,JA;FT1941,FX1941
AMPLITUDE (LIN)
4
3
2
1
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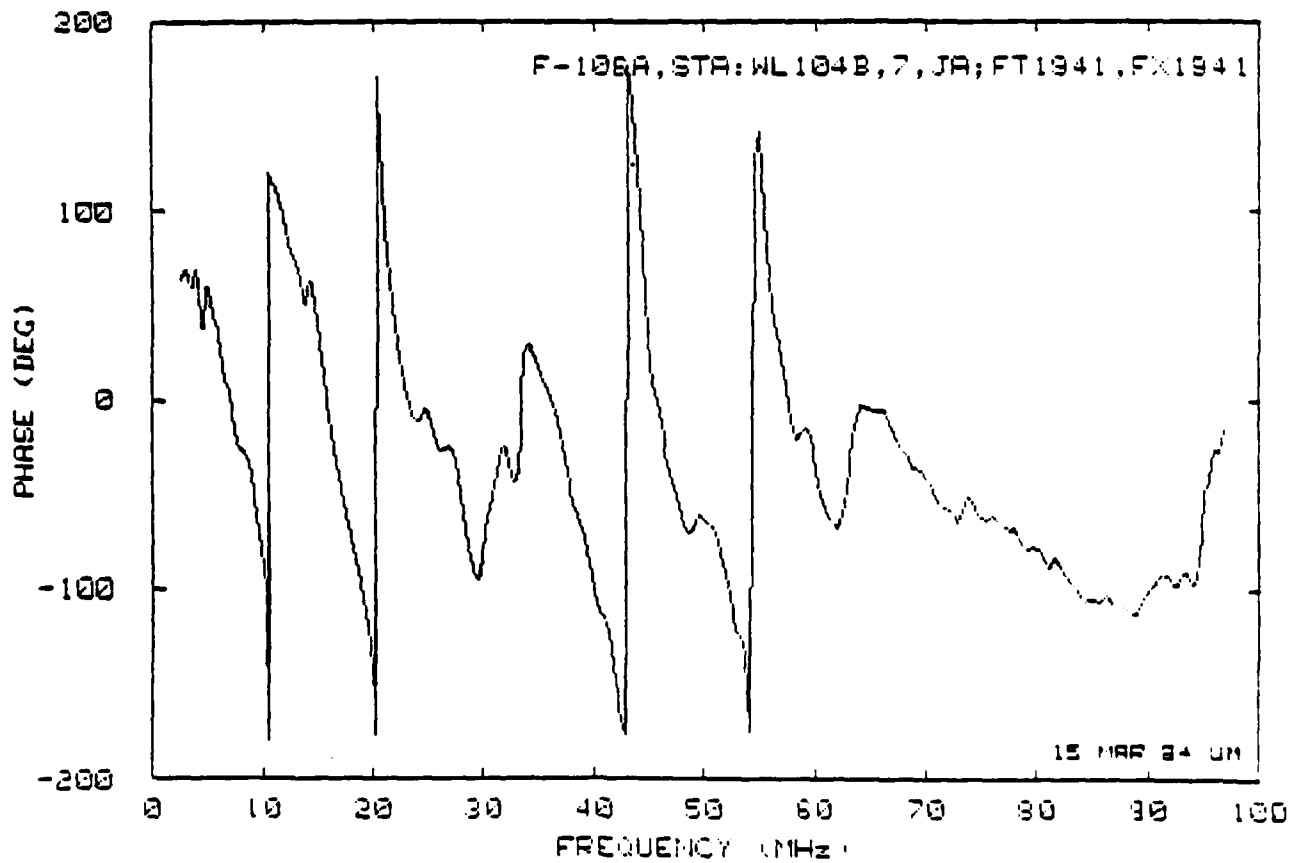
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL104B,7,JA;FT1941,FX1941
PHASE (DEG)
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-100
-200
0
10
20
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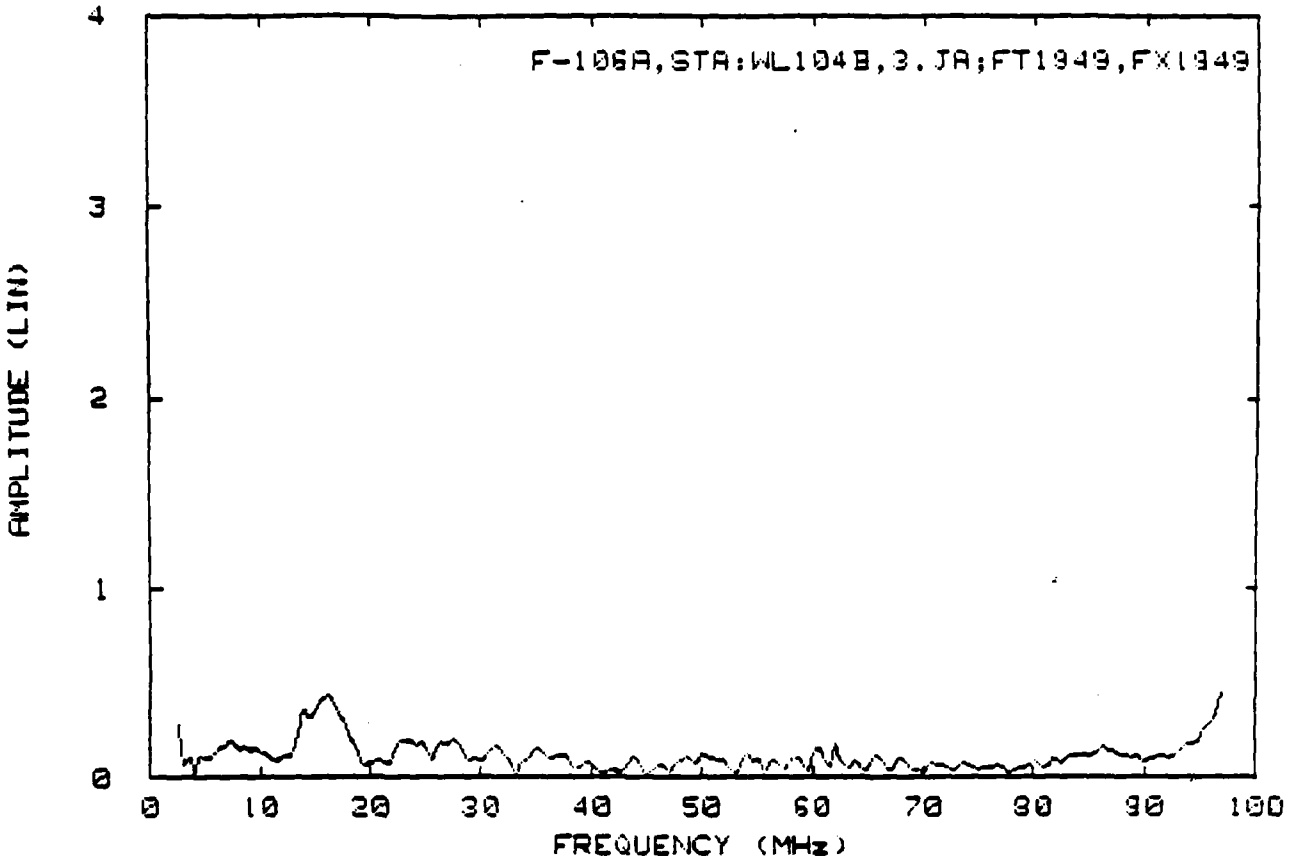
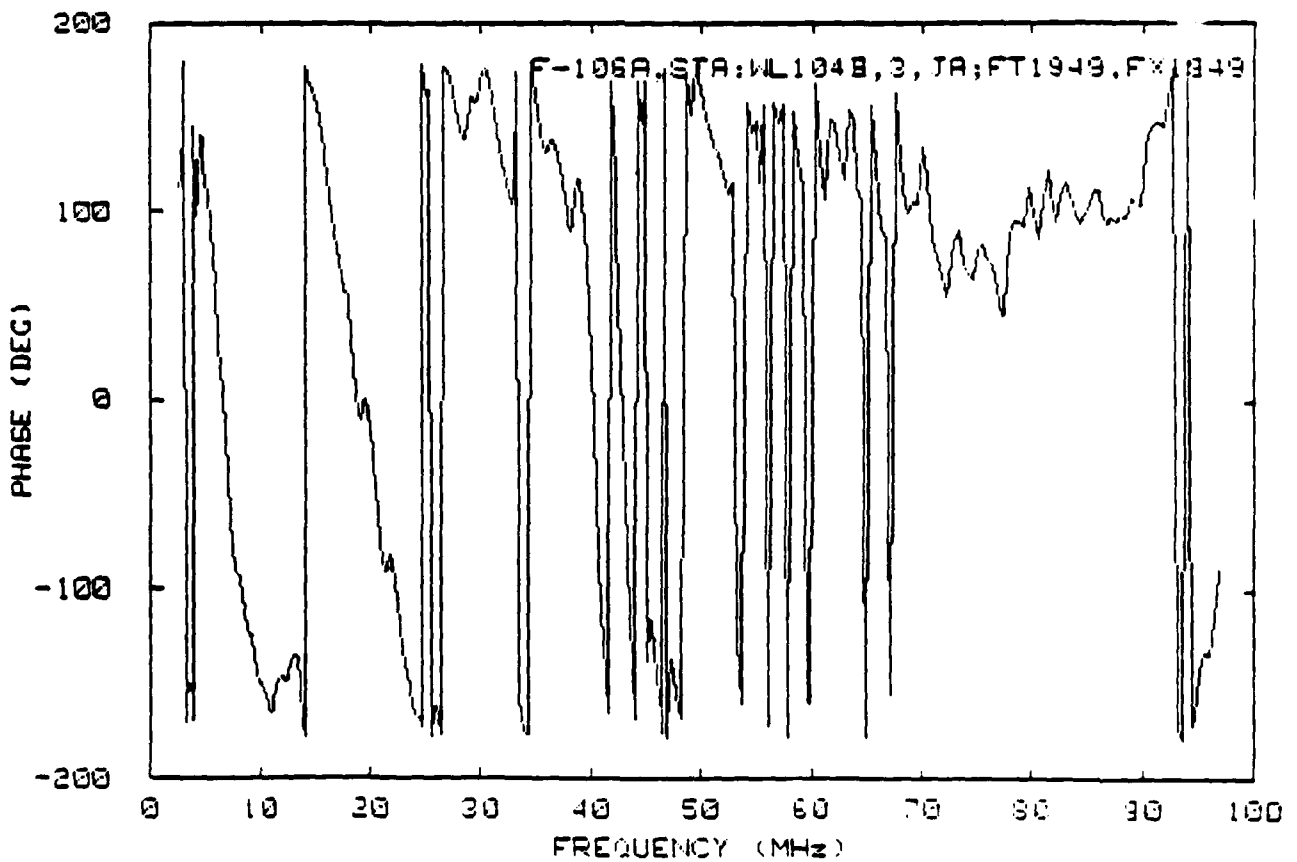
70
80
90
100
FREQUENCY (MHz)
15 MAR 84 UM


F-106A,STA:WL1048,3,JA;FT1949,FX1949
AMPLITUDE (LIN)
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:WL1048,3,JA;FT1949,FX1949
PHASE (DEG)
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100
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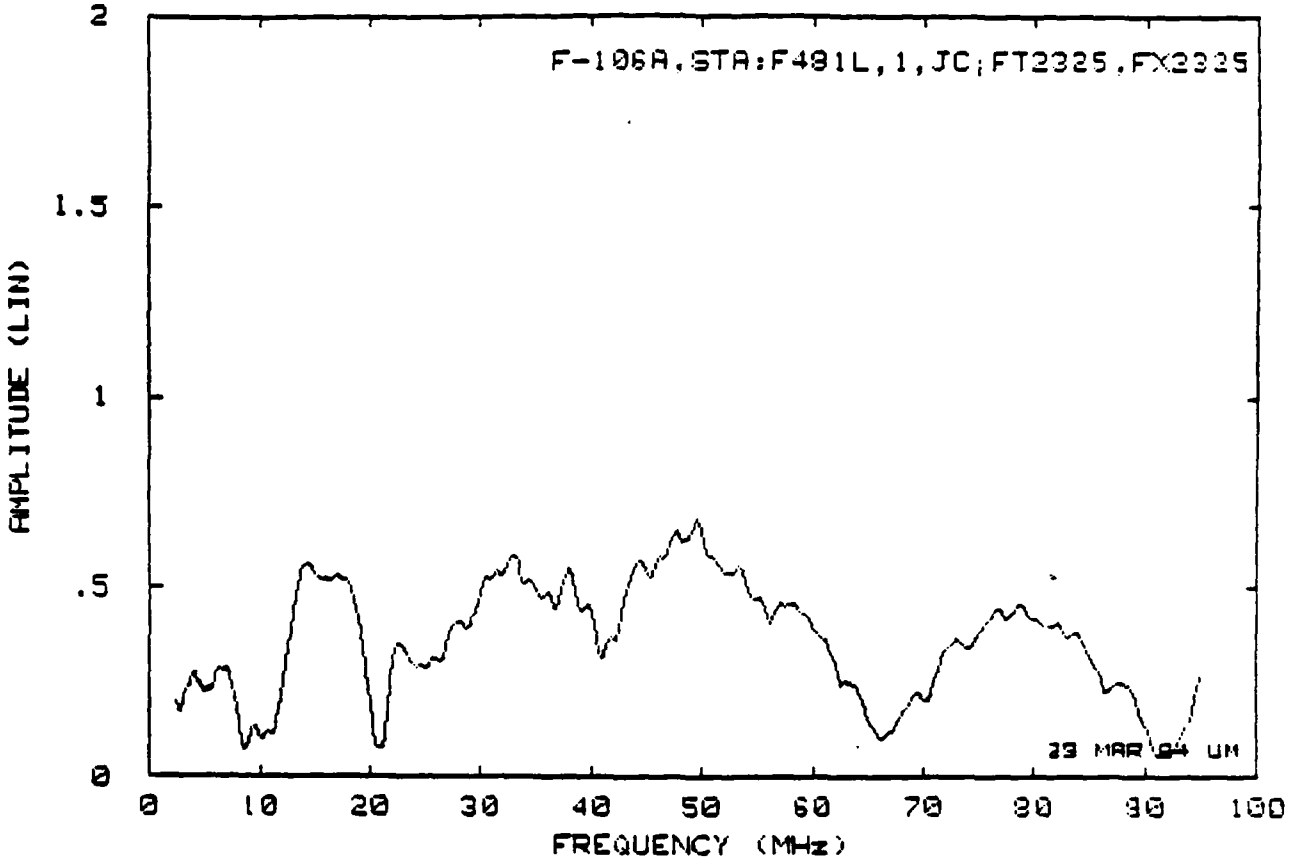
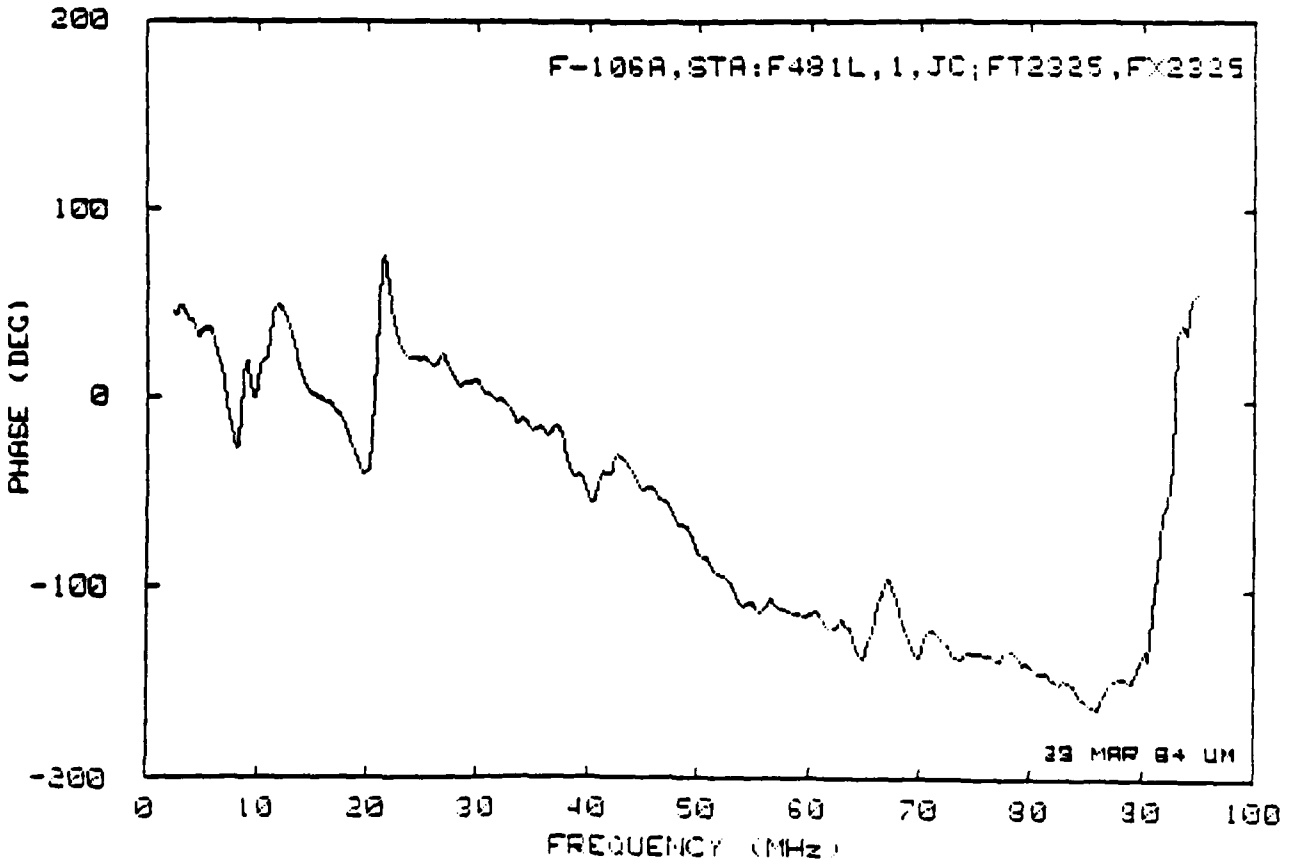
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:F481L,1,JC;FT2325,FX2325
AMPLITUDE (LIN)
2
1.5
1
.5
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
23 MAR 84 UM


F-106A,STA:F481L,1,JC;FT2325,FX2325
PHASE (DEG)
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-100
-200
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20
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40
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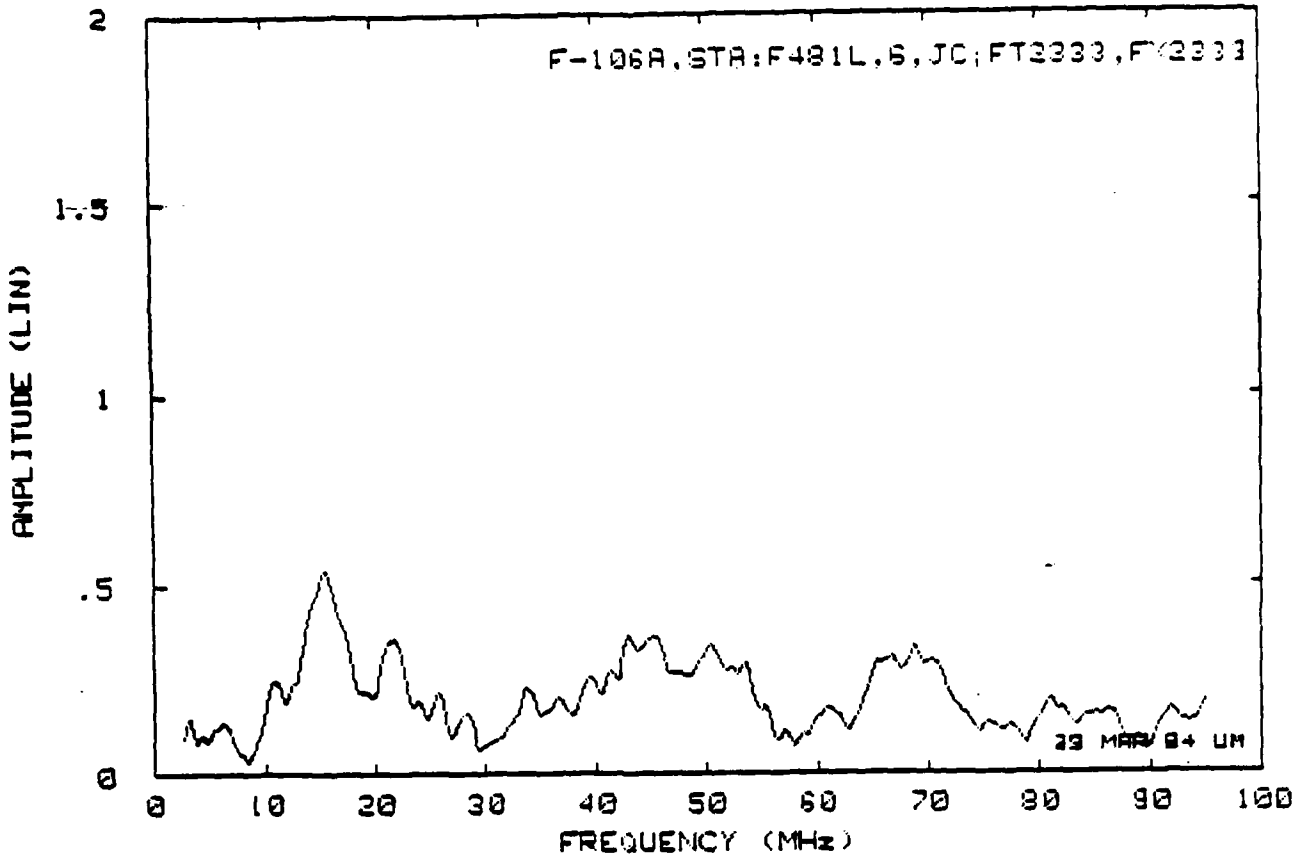
80
90
100
FREQUENCY (MHz)
23 MAR 84 UM


F-106A,STA:F481L,S,JC;FT2333,FX2333
AMPLITUDE (LIN)
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1.5
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10
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80
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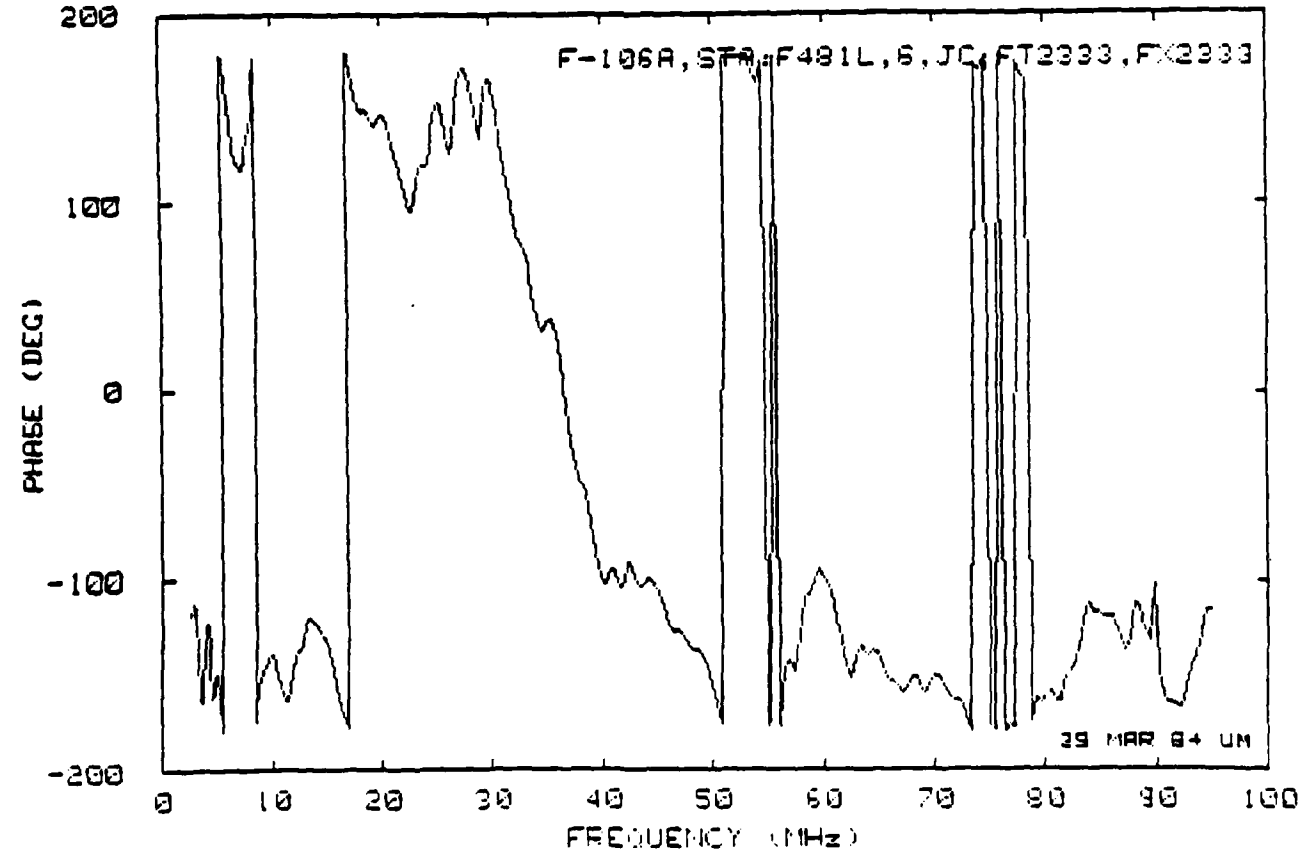
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,S,JC;FT2333,FX2333
PHASE (DEG)
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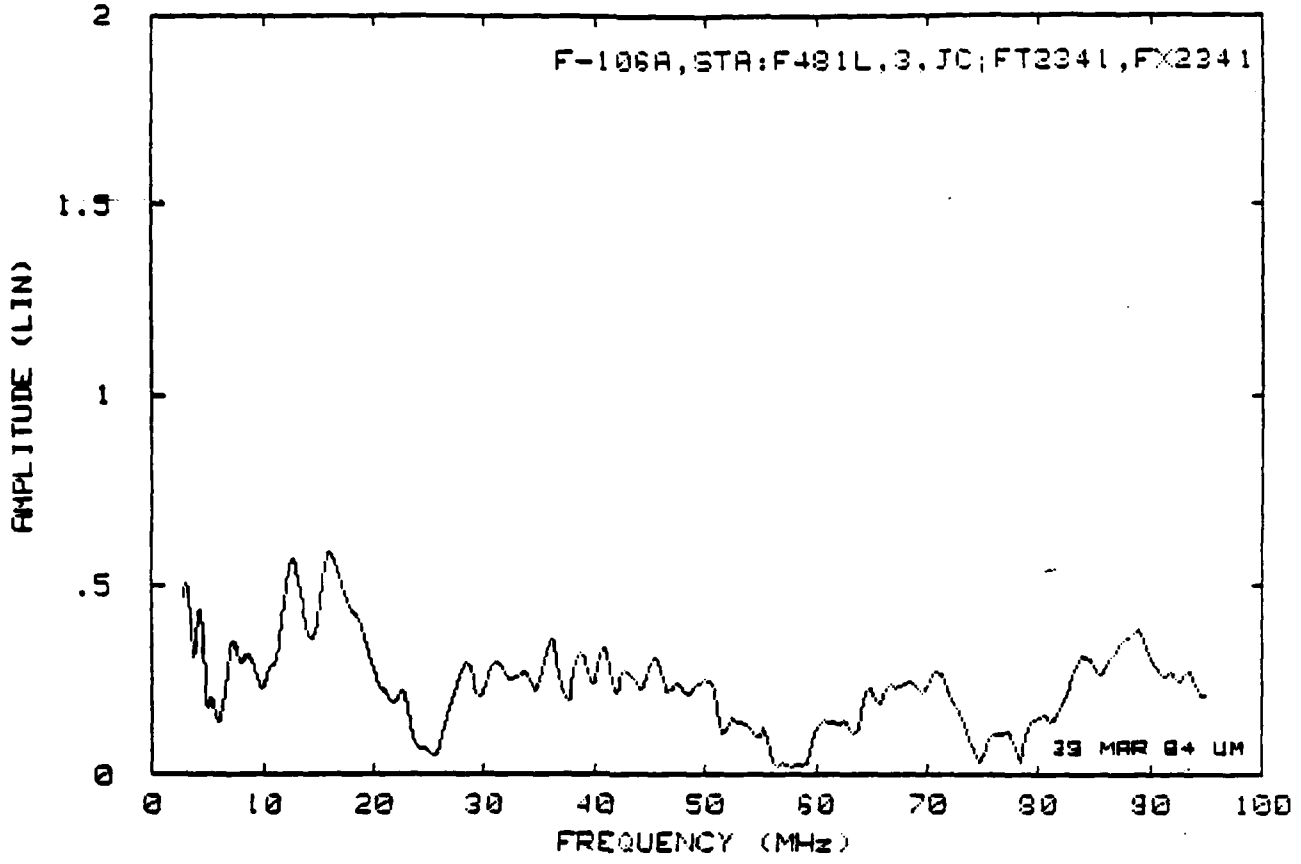
90
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,3,JC;FT2341,FX2341
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10
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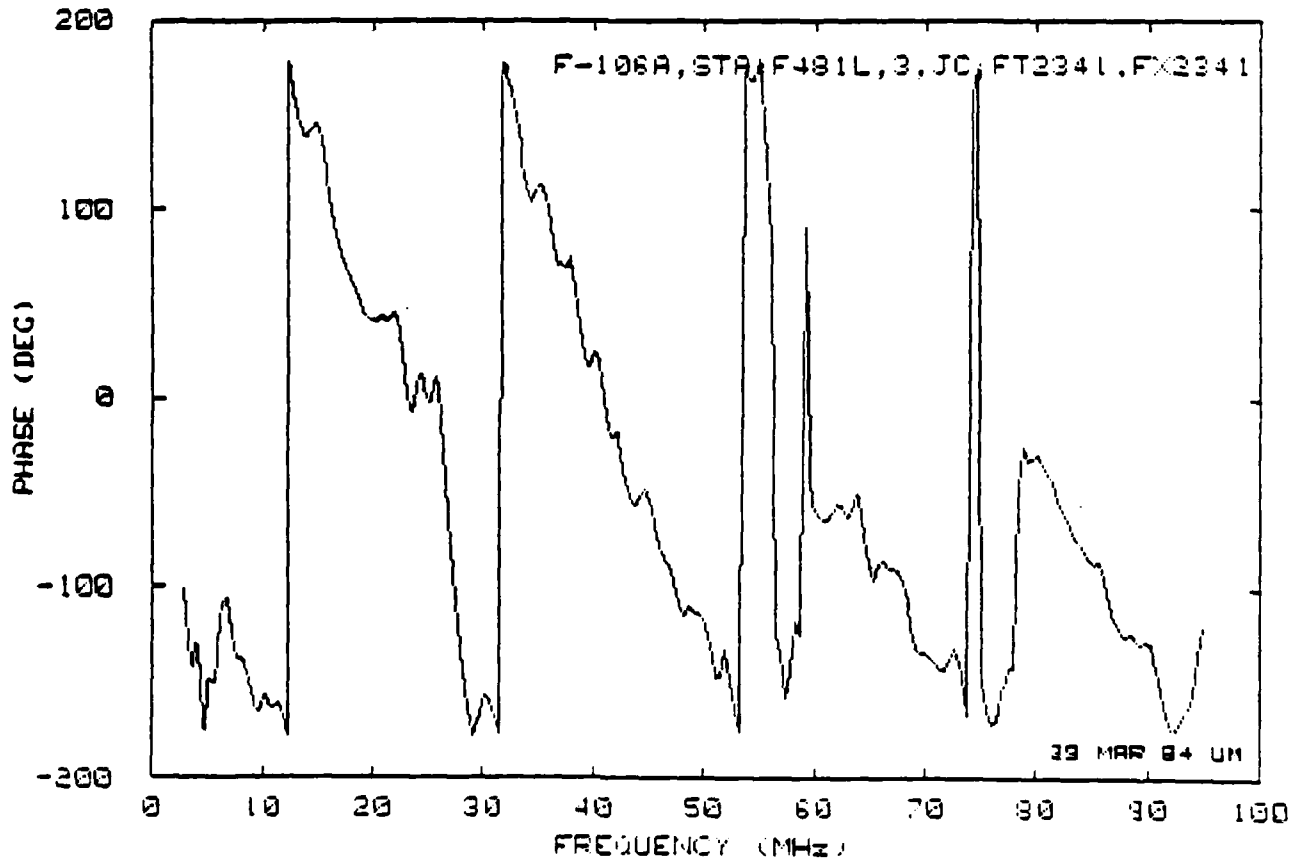
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,3,JC;FT2341,FX2341
PHASE (DEG)
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-100
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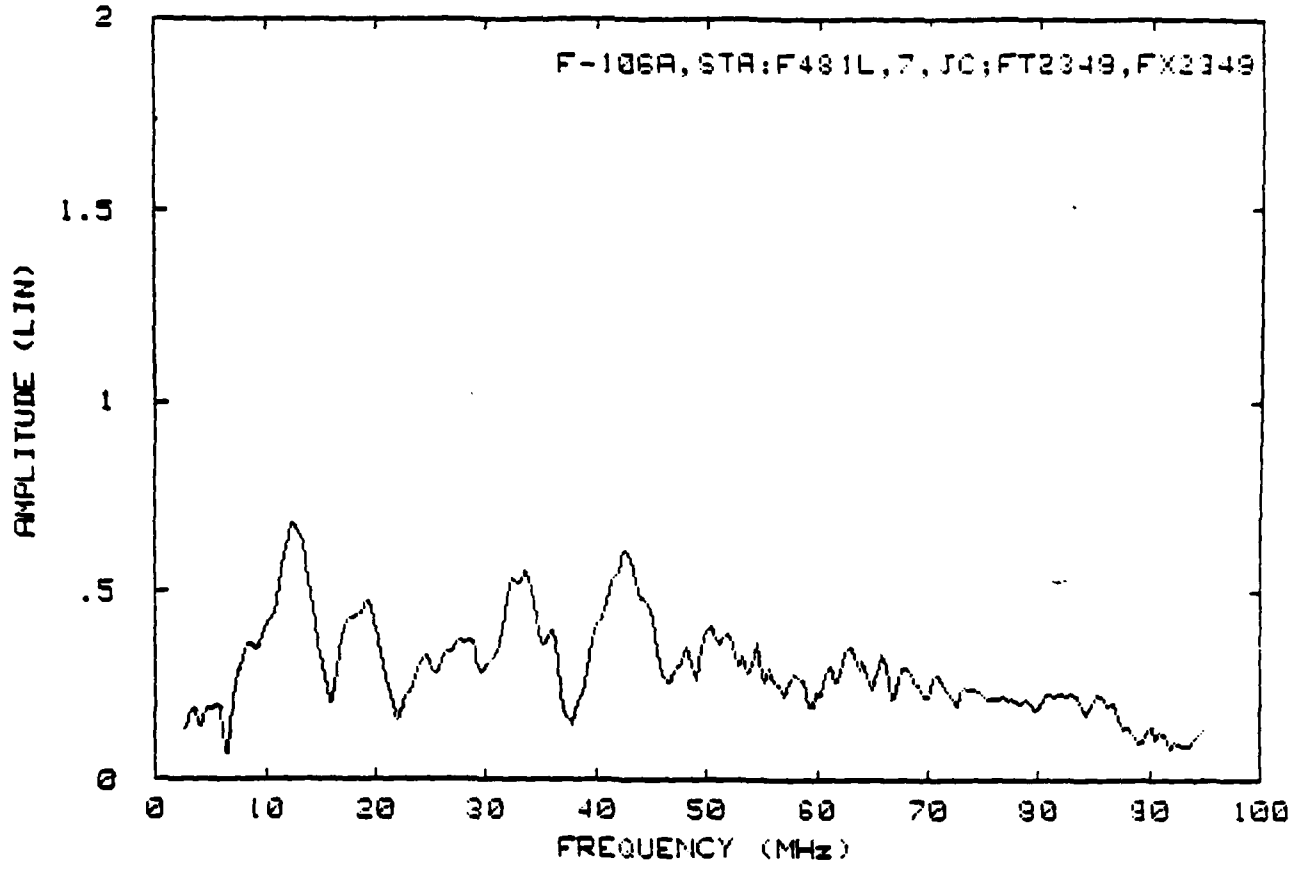
80
90
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,7,JC;FT2349,FX2349
AMPLITUDE (LIN)
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1.5
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0
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10
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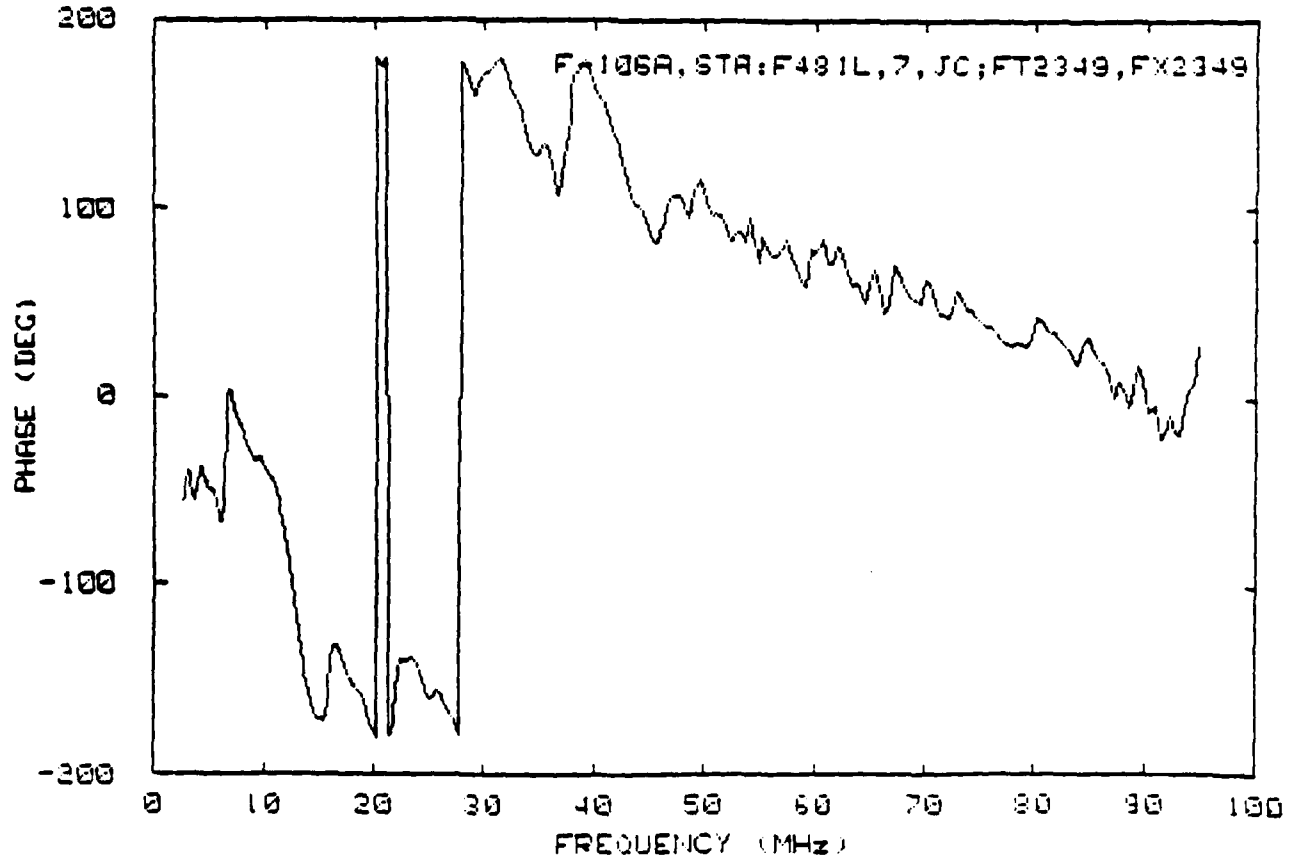
90
100
FREQUENCY (MHz)


F-106A,STA:F481L,7,JC;FT2349,FX2349
PHASE (DEG)
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-100
-200
0
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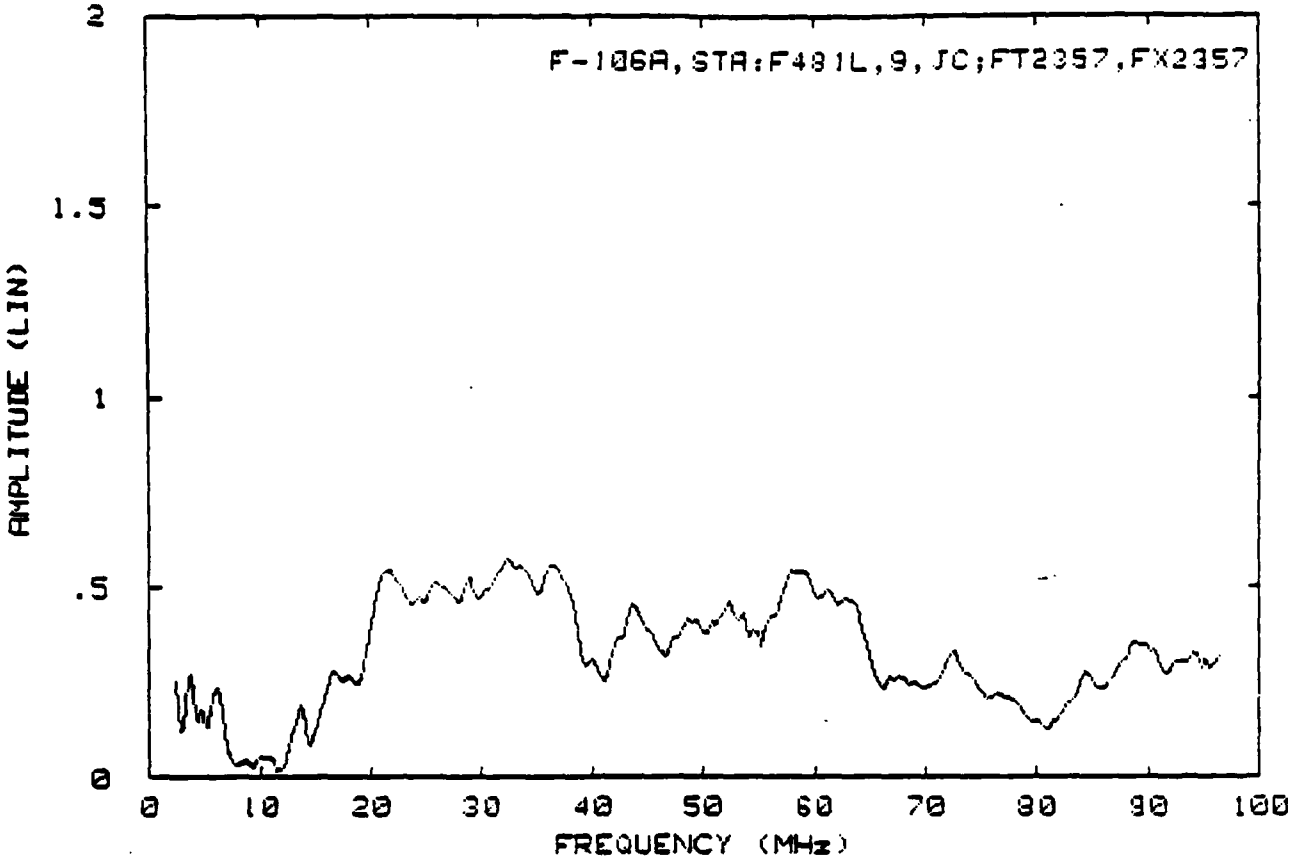
60
70
80
90
100
FREQUENCY (MHz)


F-106A, STA:F481L,9,JC;FT2357,FX2357
AMPLITUDE (LIN)
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1.5
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0
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10
20
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40
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80
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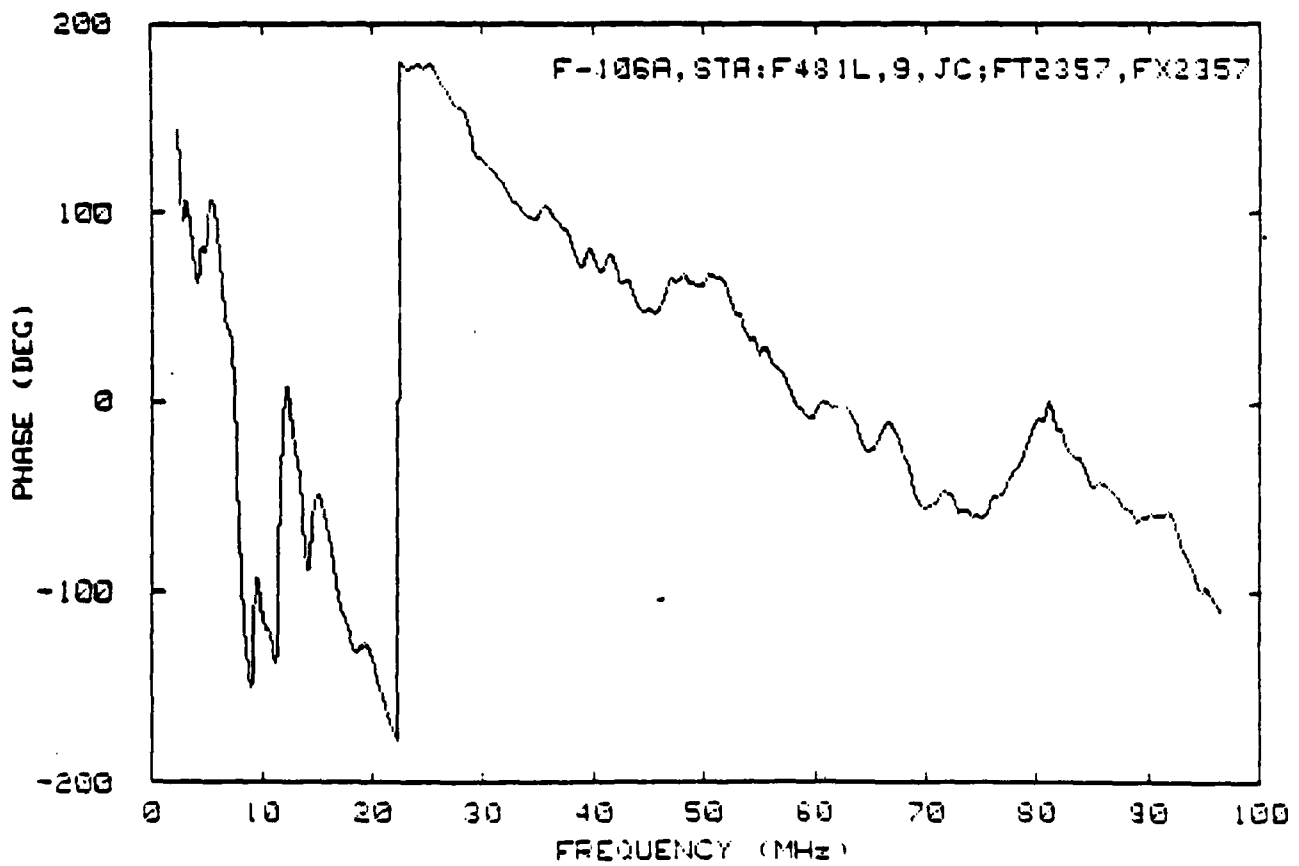
100
FREQUENCY (MHz)


F-106A, STA:F481L,9,JC;FT2357,FX2357
PHASE (DEG)
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-200
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80
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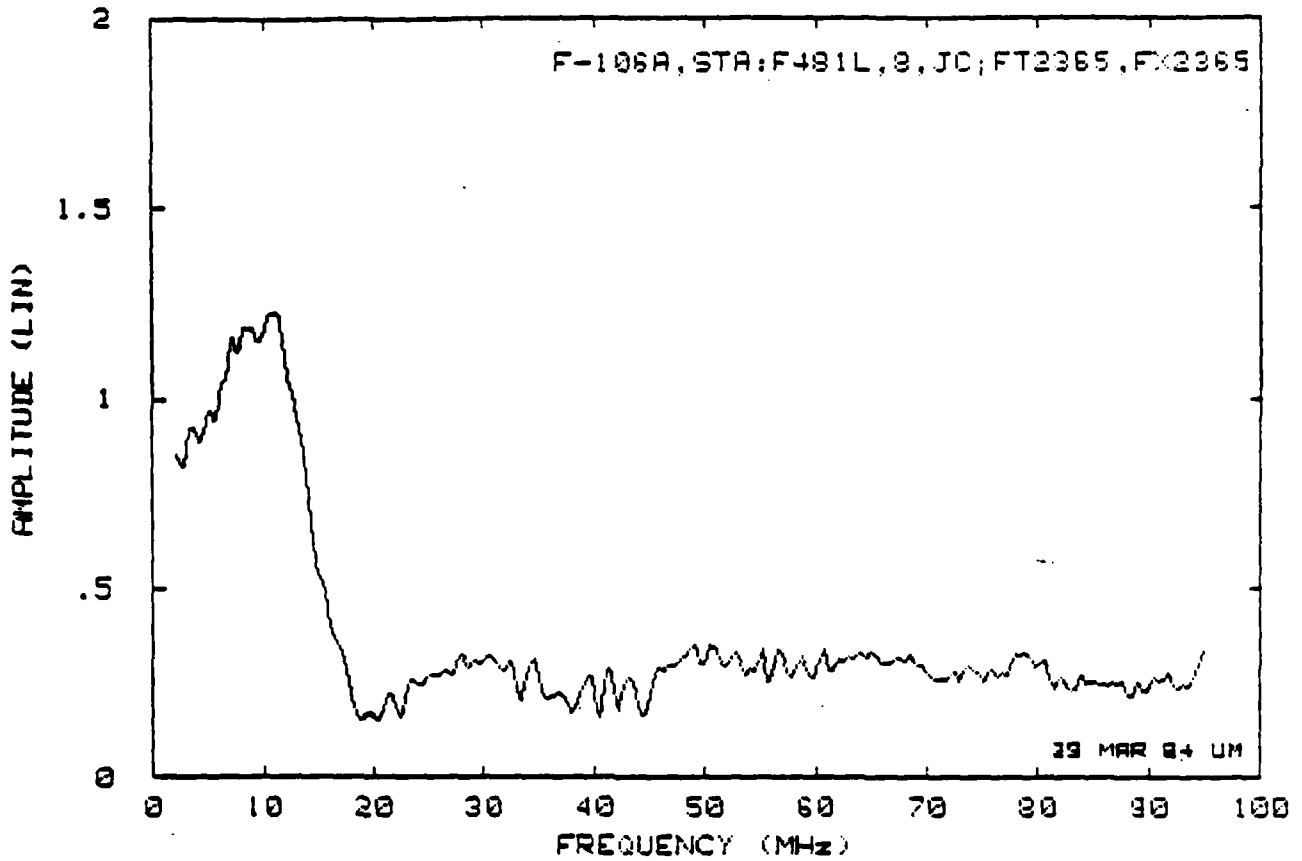
100
FREQUENCY (MHz)


F-106A,STA:F481L,8,JC;FT2365,FX2365
AMPLITUDE (LIN)
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1.5
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.5
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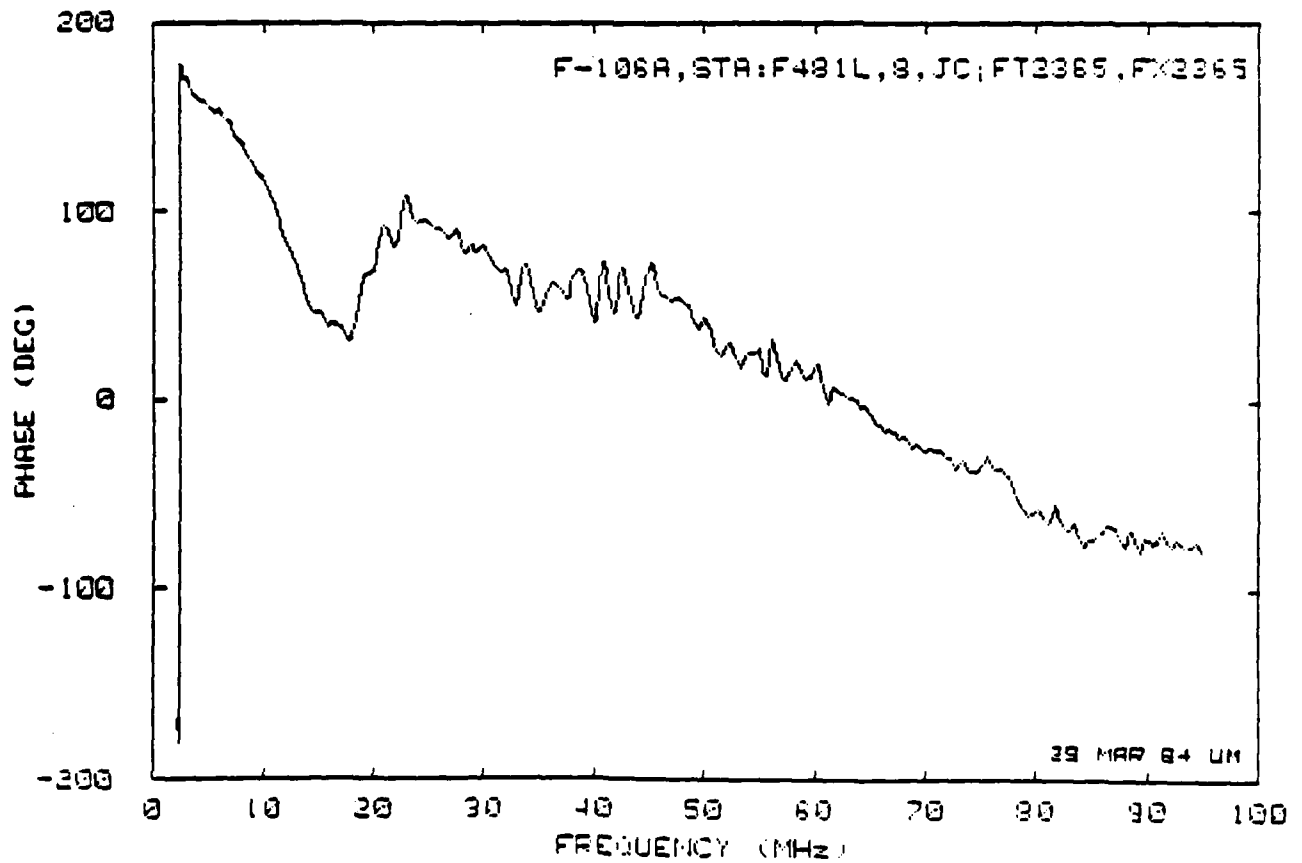
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,8,JC;FT2365,FX2365
PHASE (DEG)
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10
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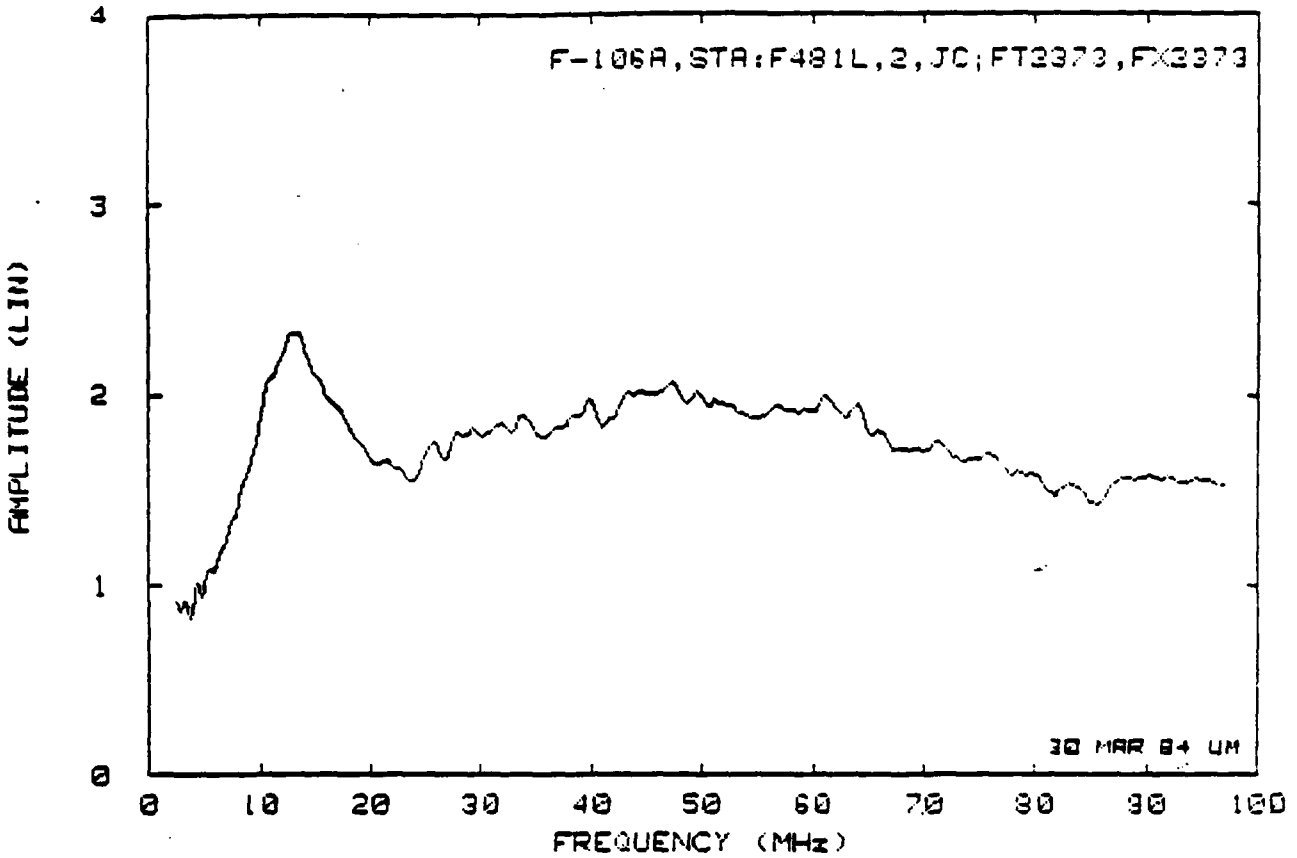
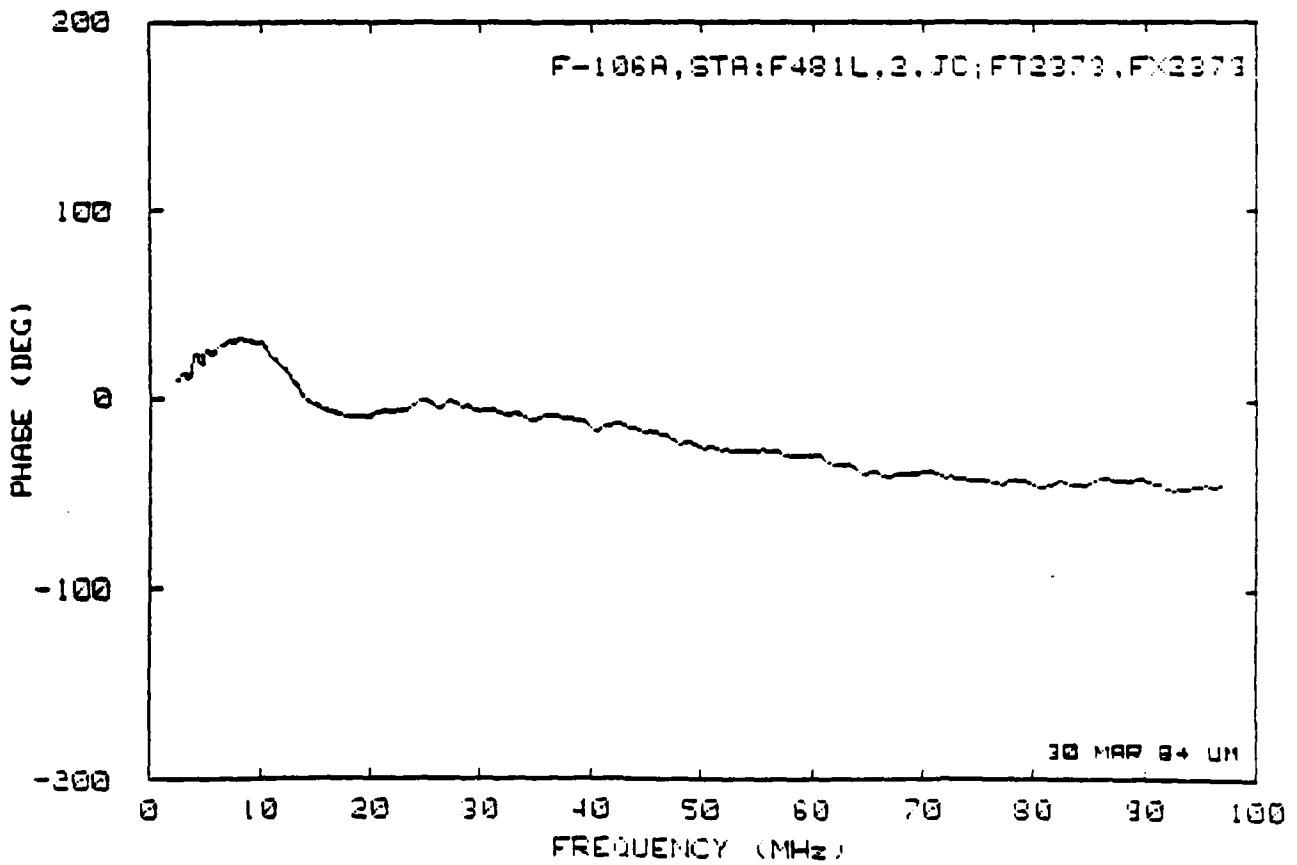
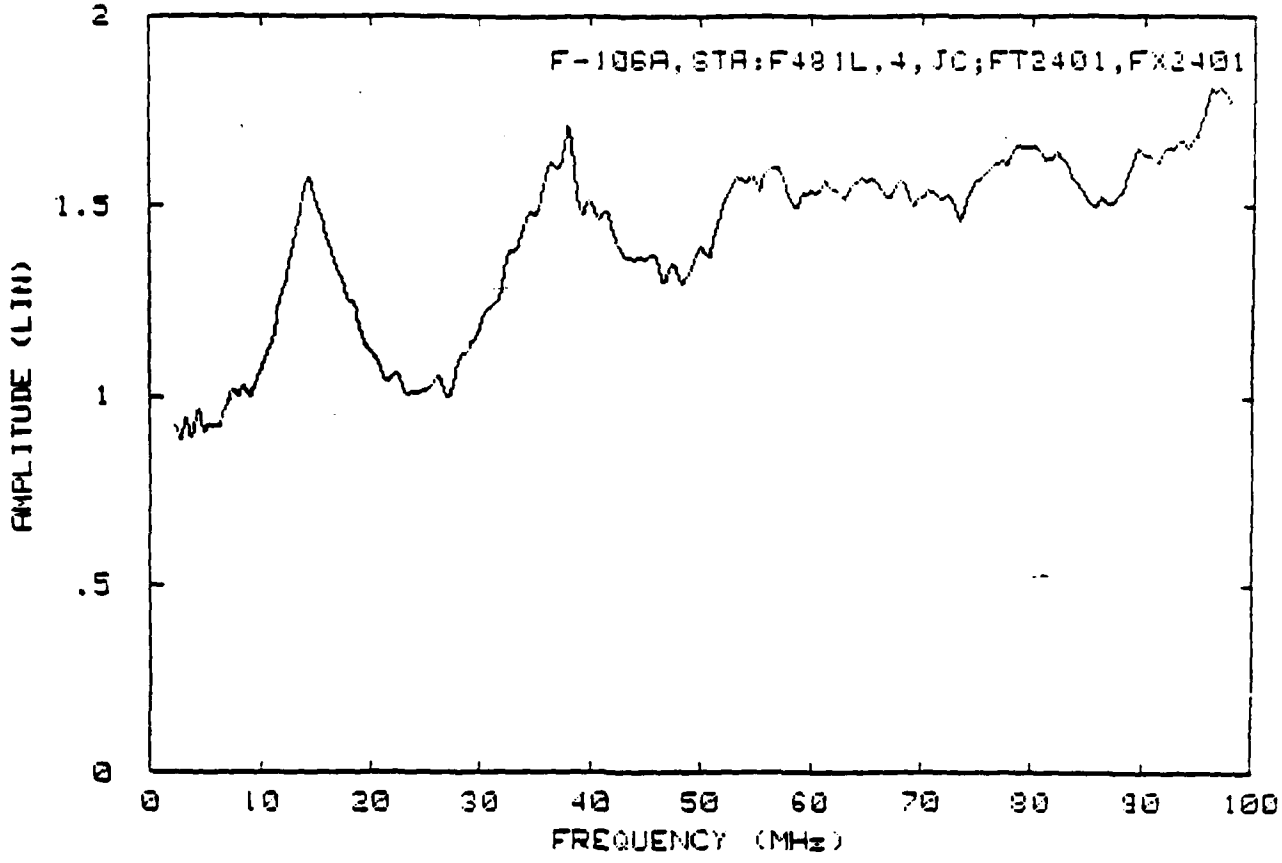
100
FREQUENCY (MHz)
29 MAR 84 UM


F-106A,STA:F481L,2,JC;FT2373,FX2373
AMPLITUDE (LIN)
4
3
2
1
0
30 MAR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A,STA:F481L,2,JC;FT2373,FX2373
PHASE (DEG)
200
100
0
-100
-200
30 MAR 84 UM
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A, STA:F481L,4, JC;FT2401,FX2401
AMPLITUDE (LIN)
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1.5
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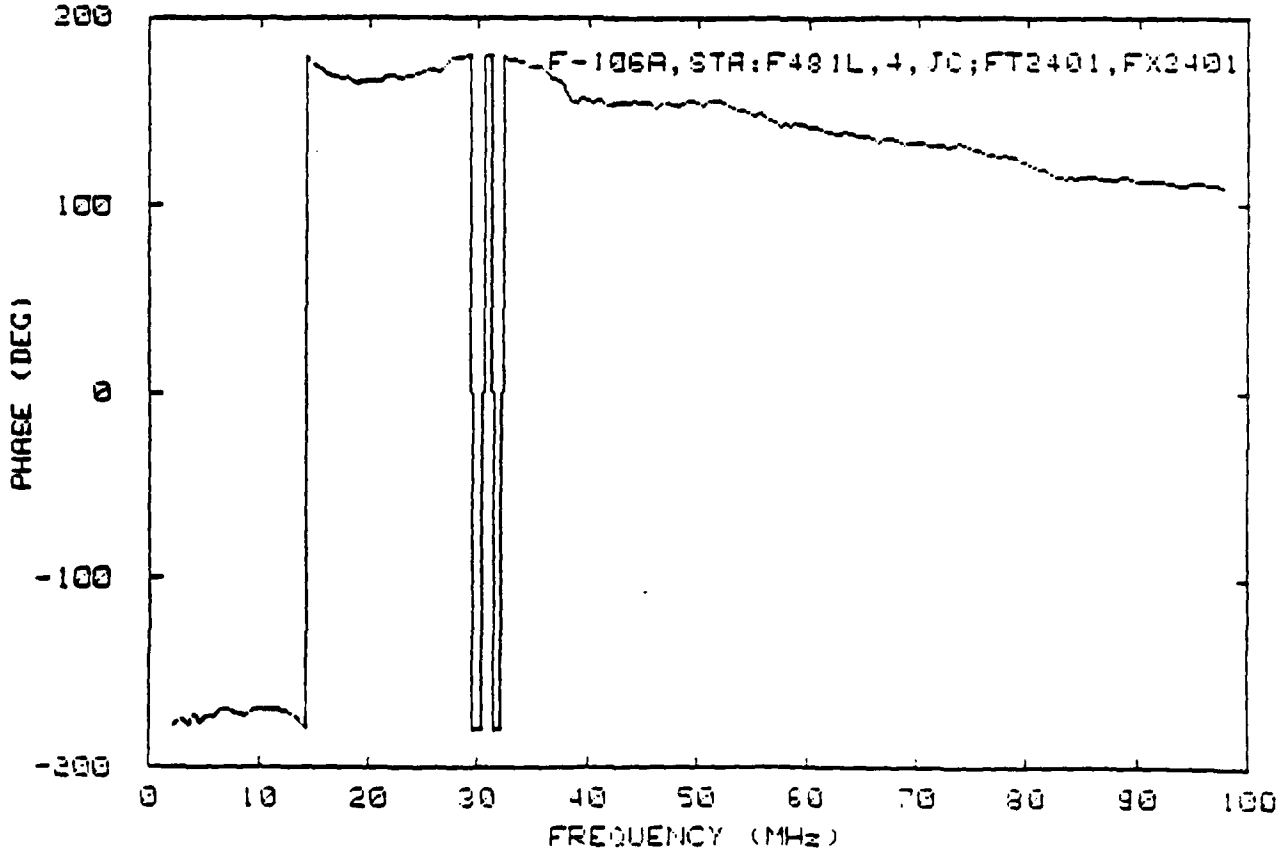
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)


F-106A, STA:F481L,4, JC;FT2401,FX2401
PHASE (DEG)
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-100
-200
0
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20
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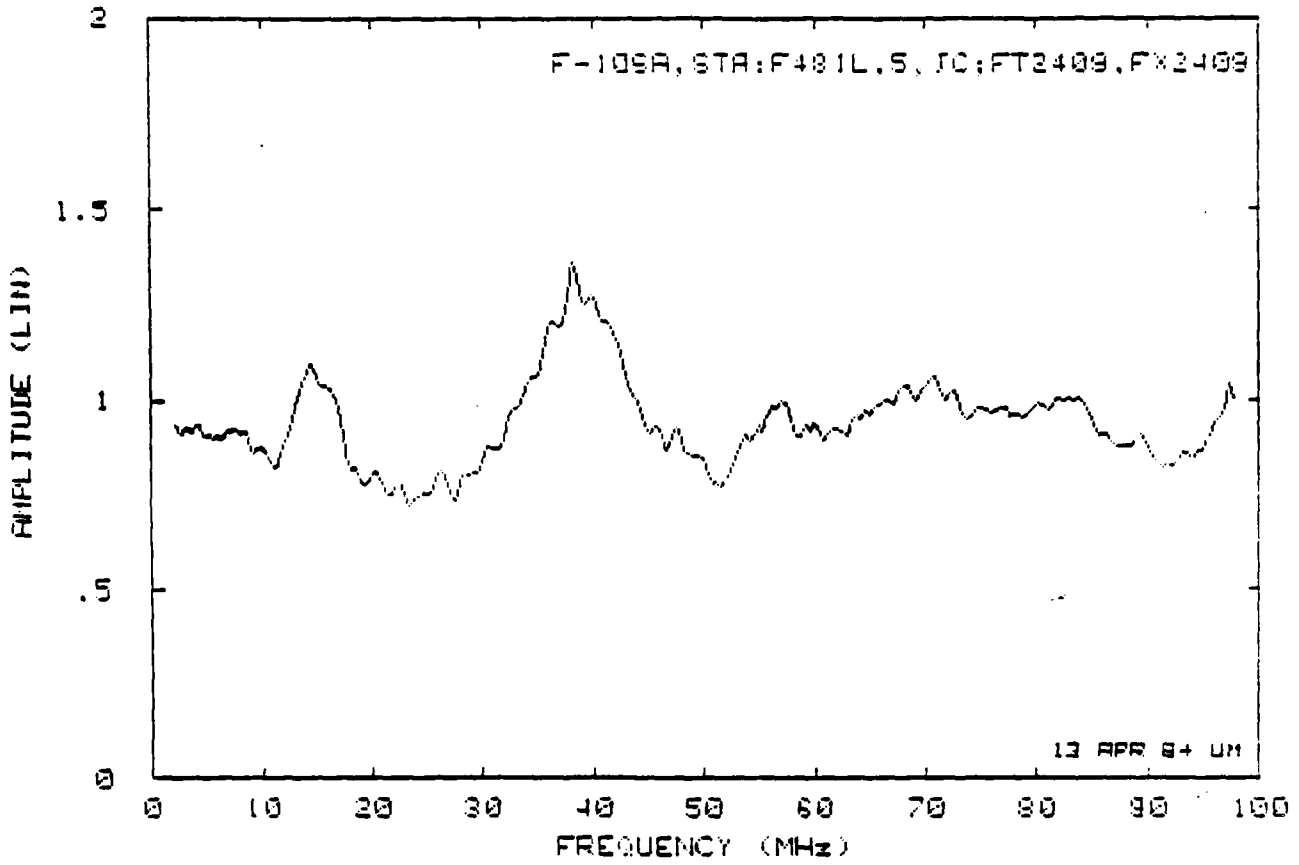
60
70
80
90
100
FREQUENCY (MHz)


F-109A,STA:F481L,S,JC;FT2409,FX2409
AMPLITUDE (LIN)
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1.5
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10
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40
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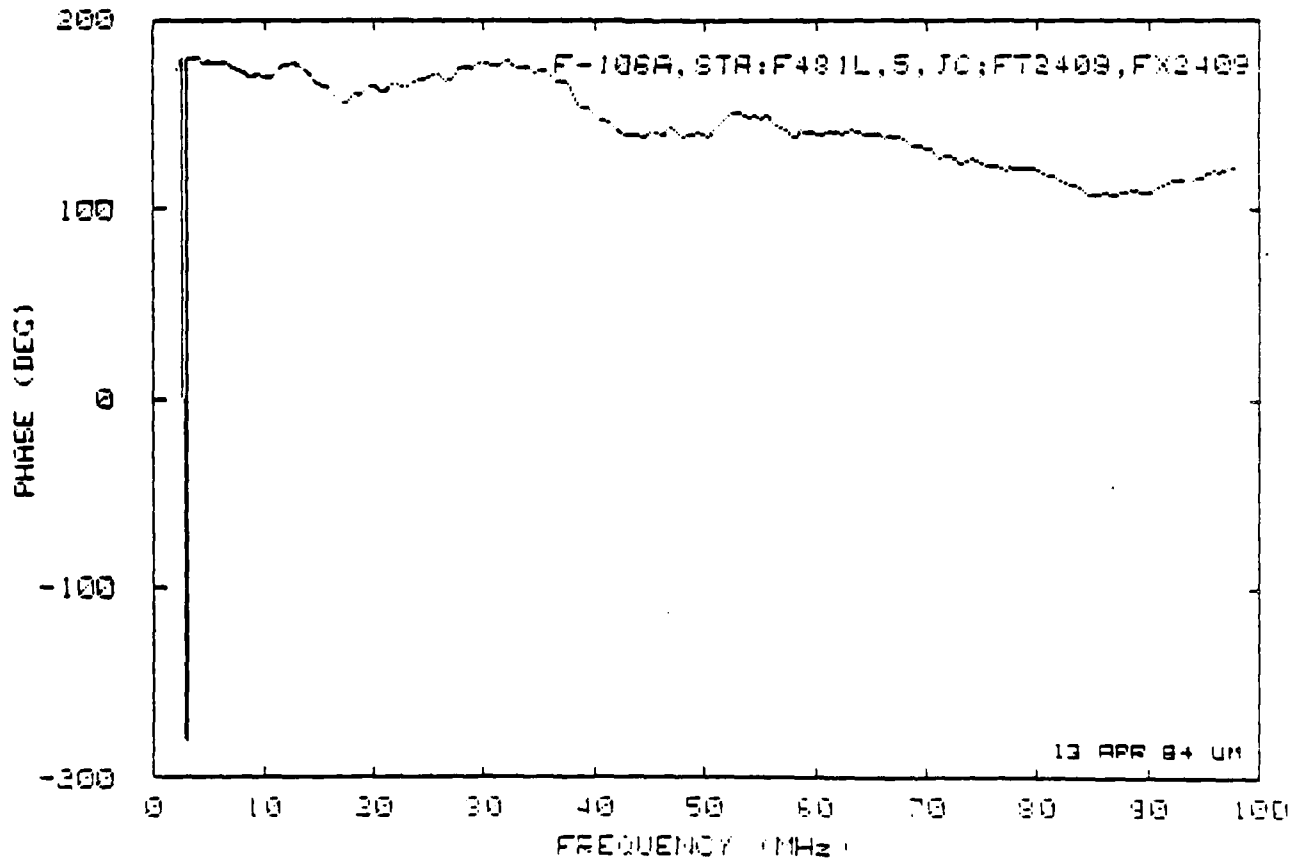
60
70
80
90
100
FREQUENCY (MHz)
13 APR 84 UM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PHASE (DEG)
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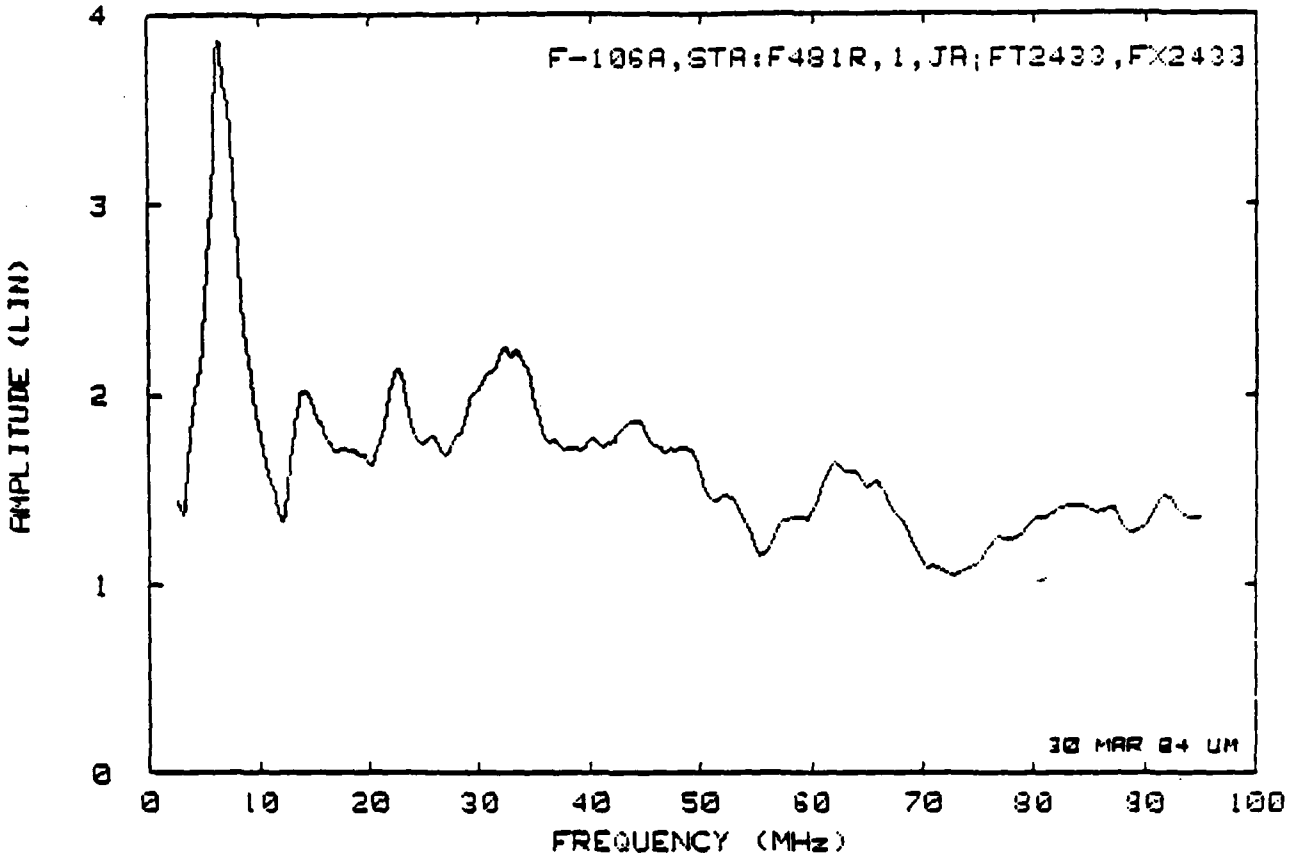
100
FREQUENCY (MHz)
13 APR 84 UM


F-106A,STA:F481R,1,JR;FT2433,FX2433
AMPLITUDE (LIN)
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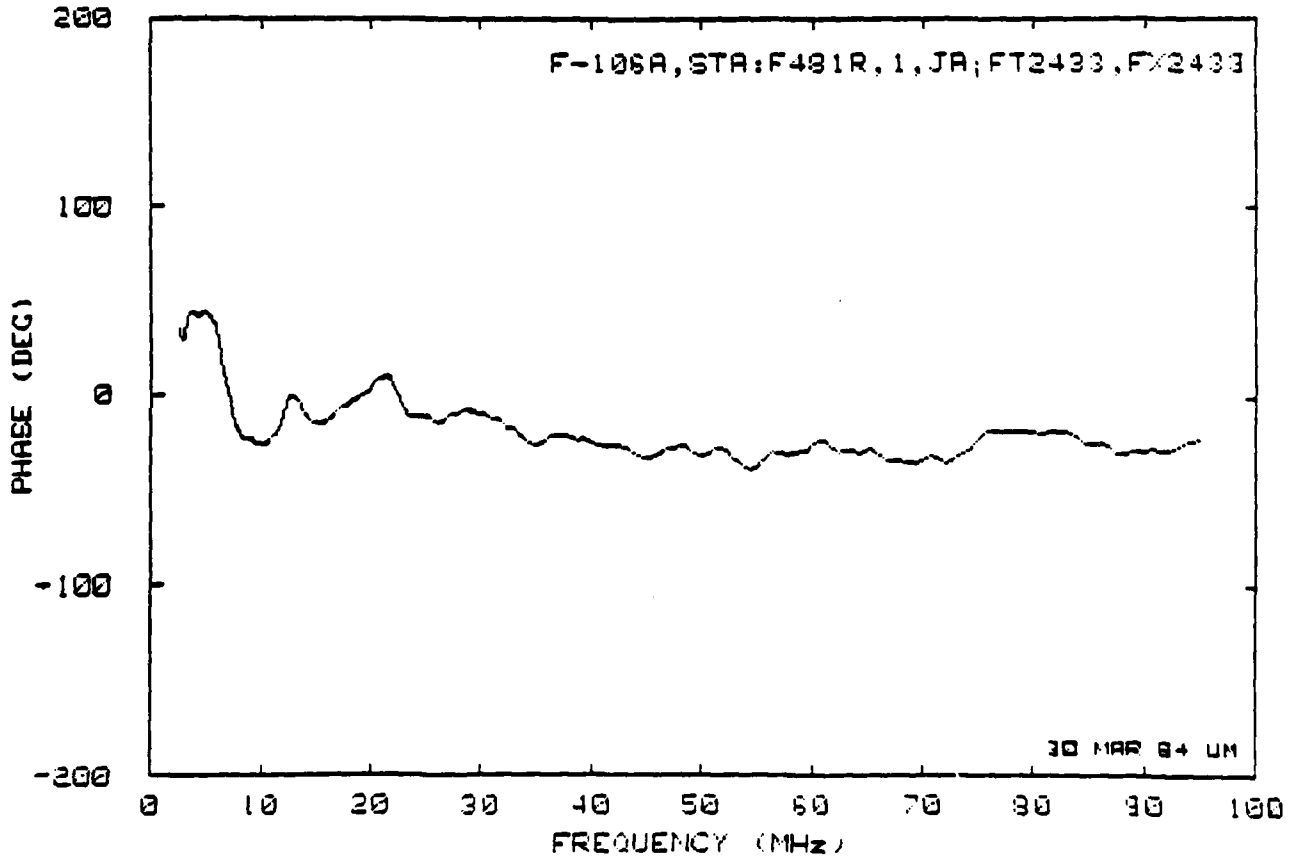
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,1,JR;FT2433,FX2433
PHASE (DEG)
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-100
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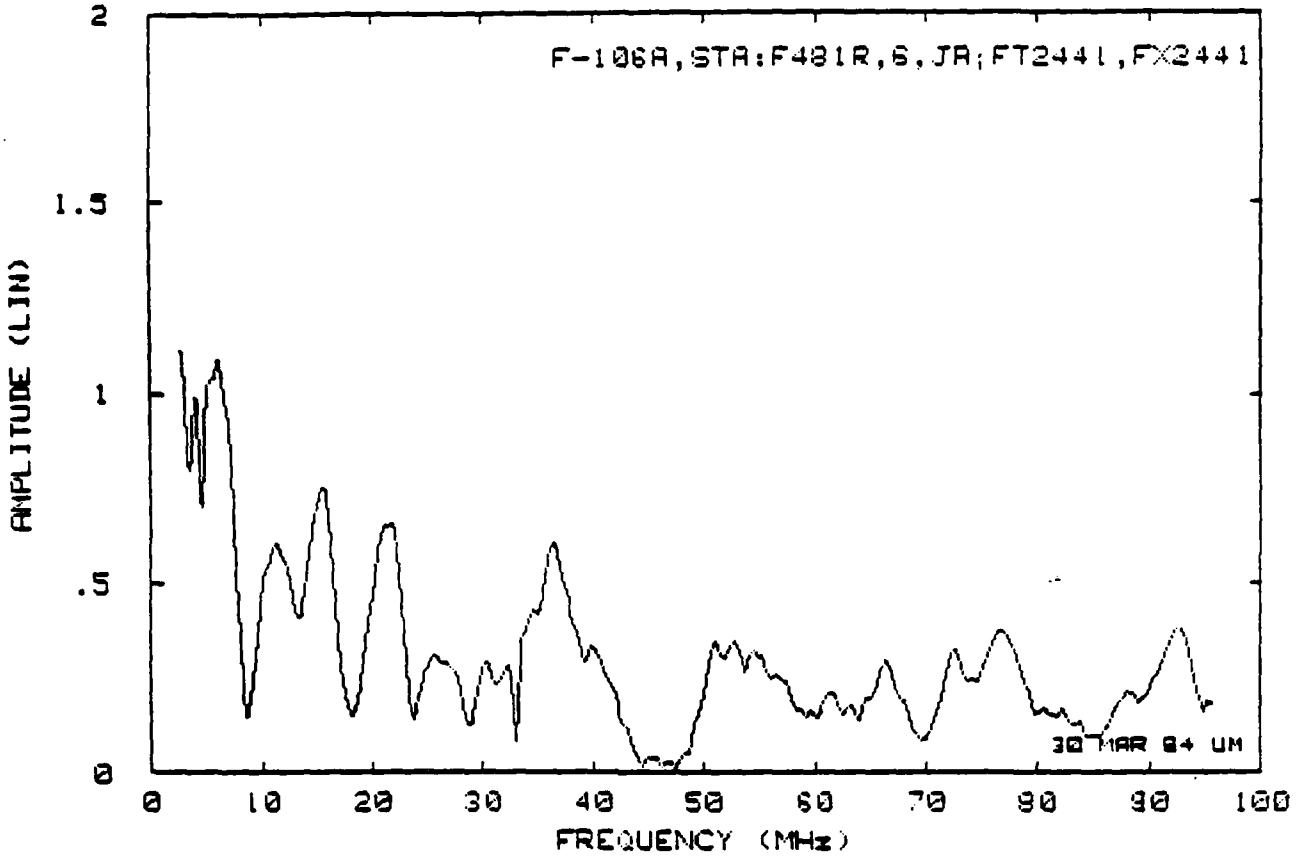
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,6,JR;FT2441,FX2441
AMPLITUDE (LIN)
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1.5
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.5
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10
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80
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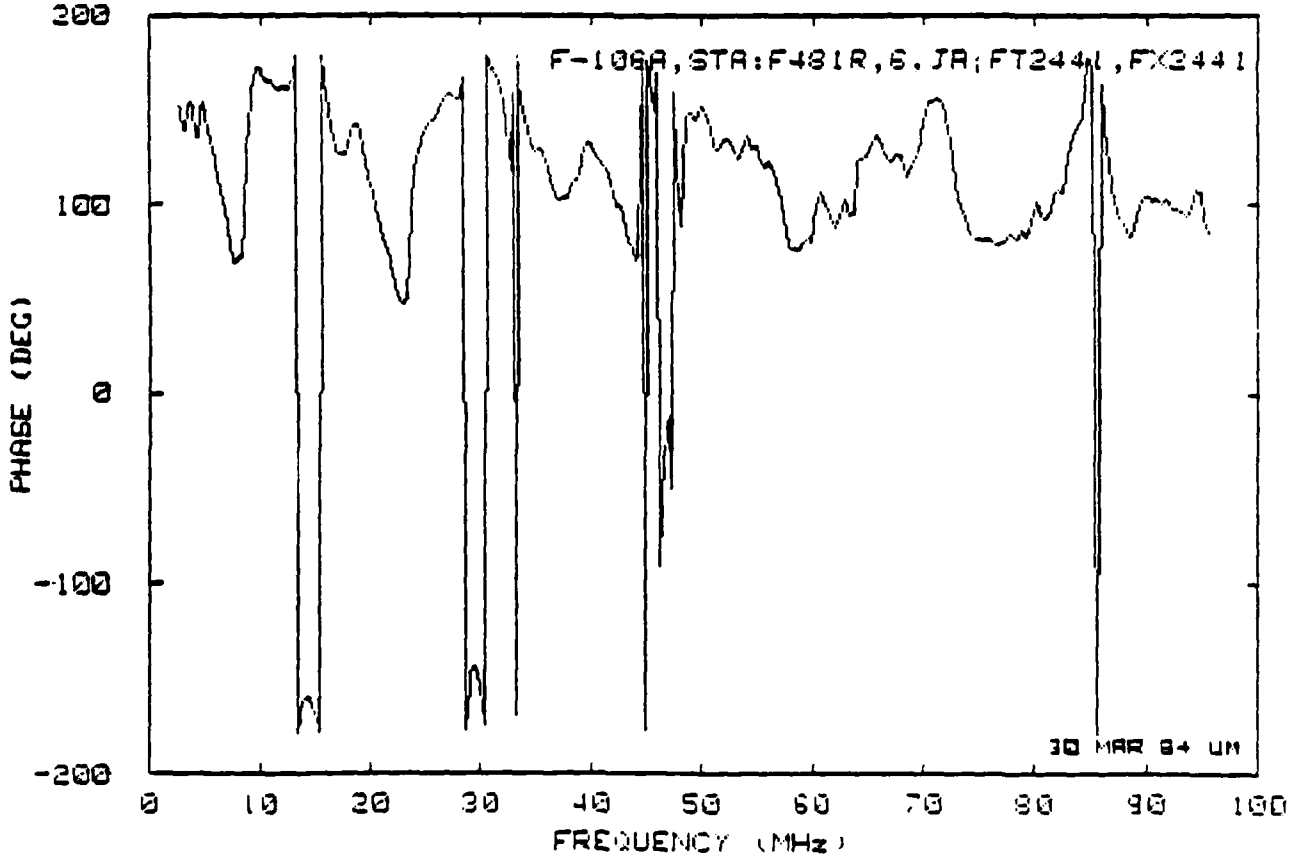
100
FREQUENCY (MHz)
30 MAR 84 UM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PHASE (DEG)
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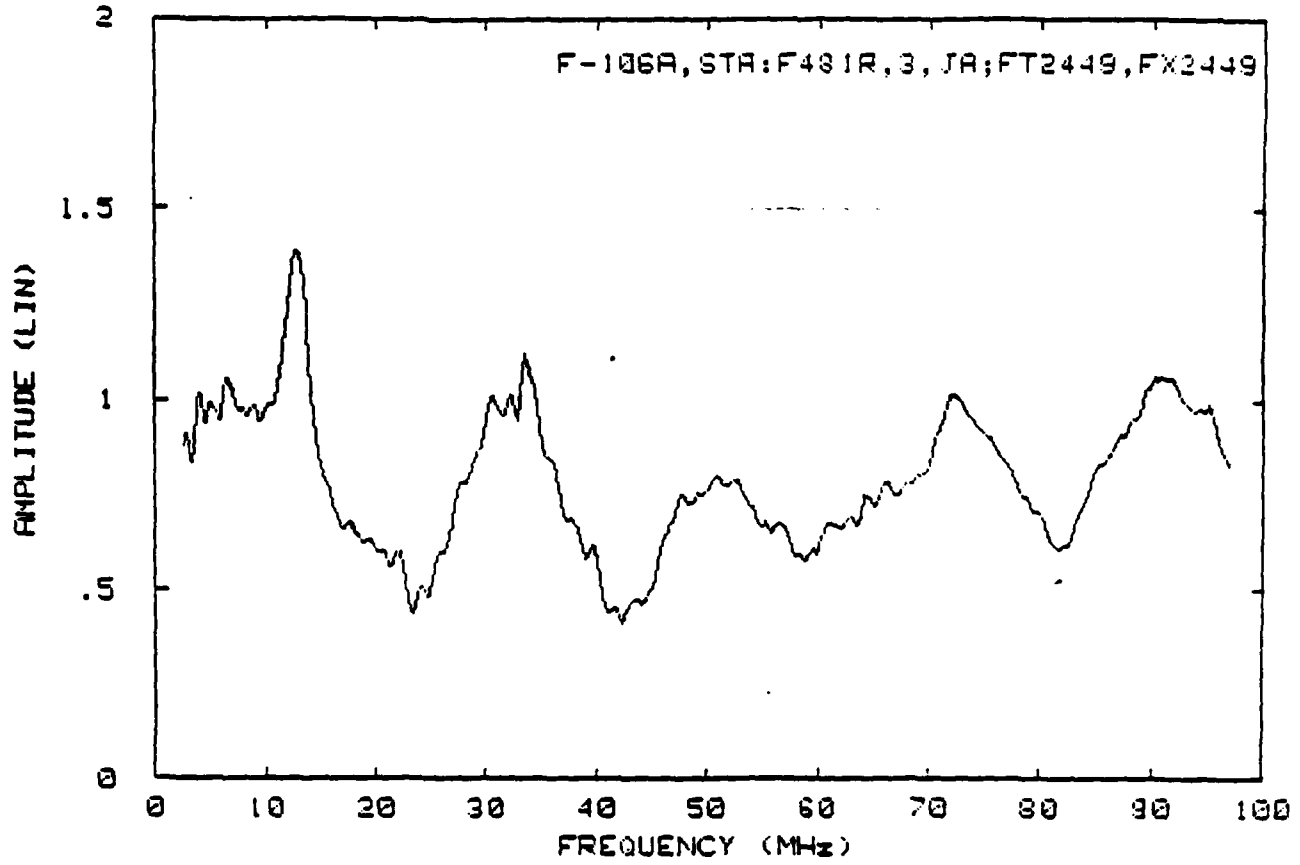
FREQUENCY (MHz)
30 MAR 84 UM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AMPLITUDE (LIN)
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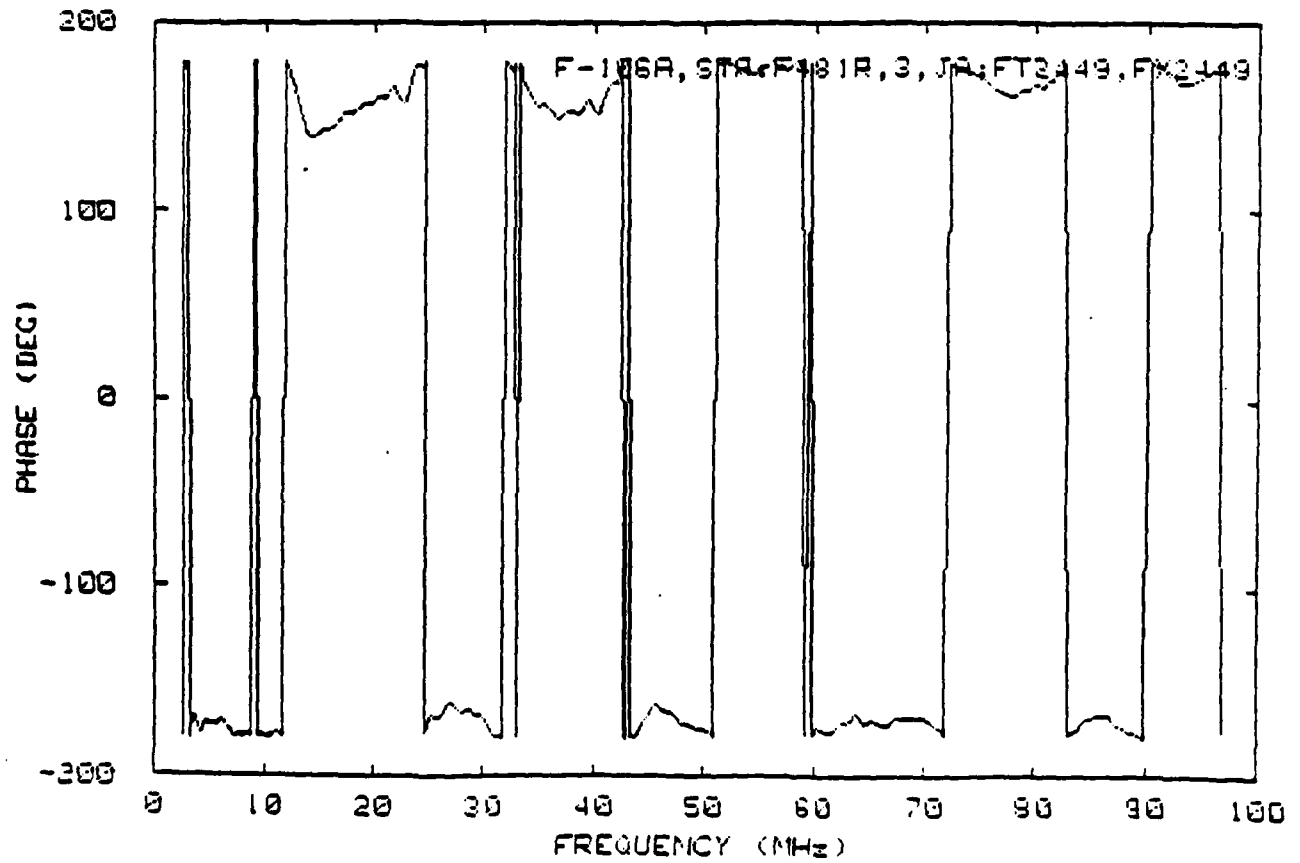
100
FREQUENCY (MHz)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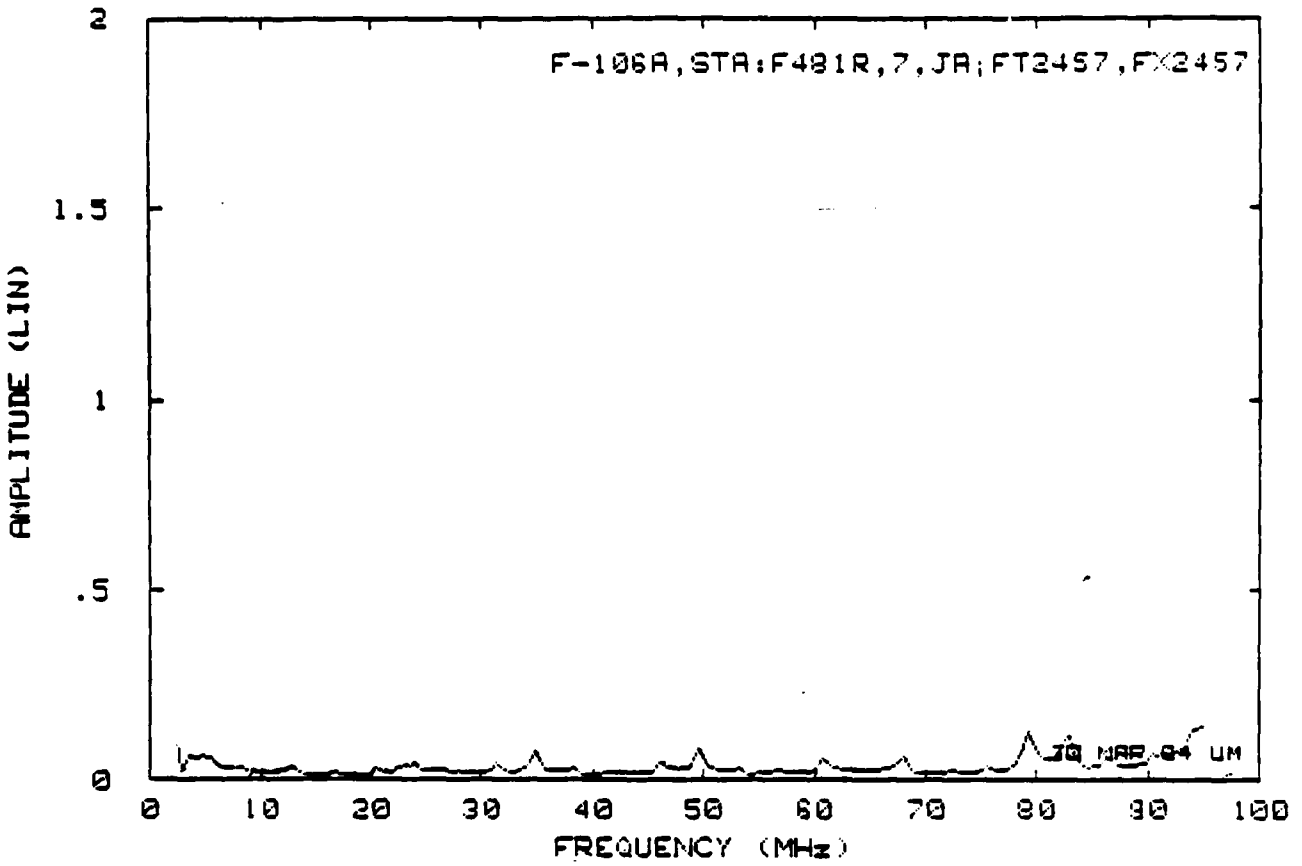
100
FREQUENCY (MHz)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AMPLITUDE (LIN)
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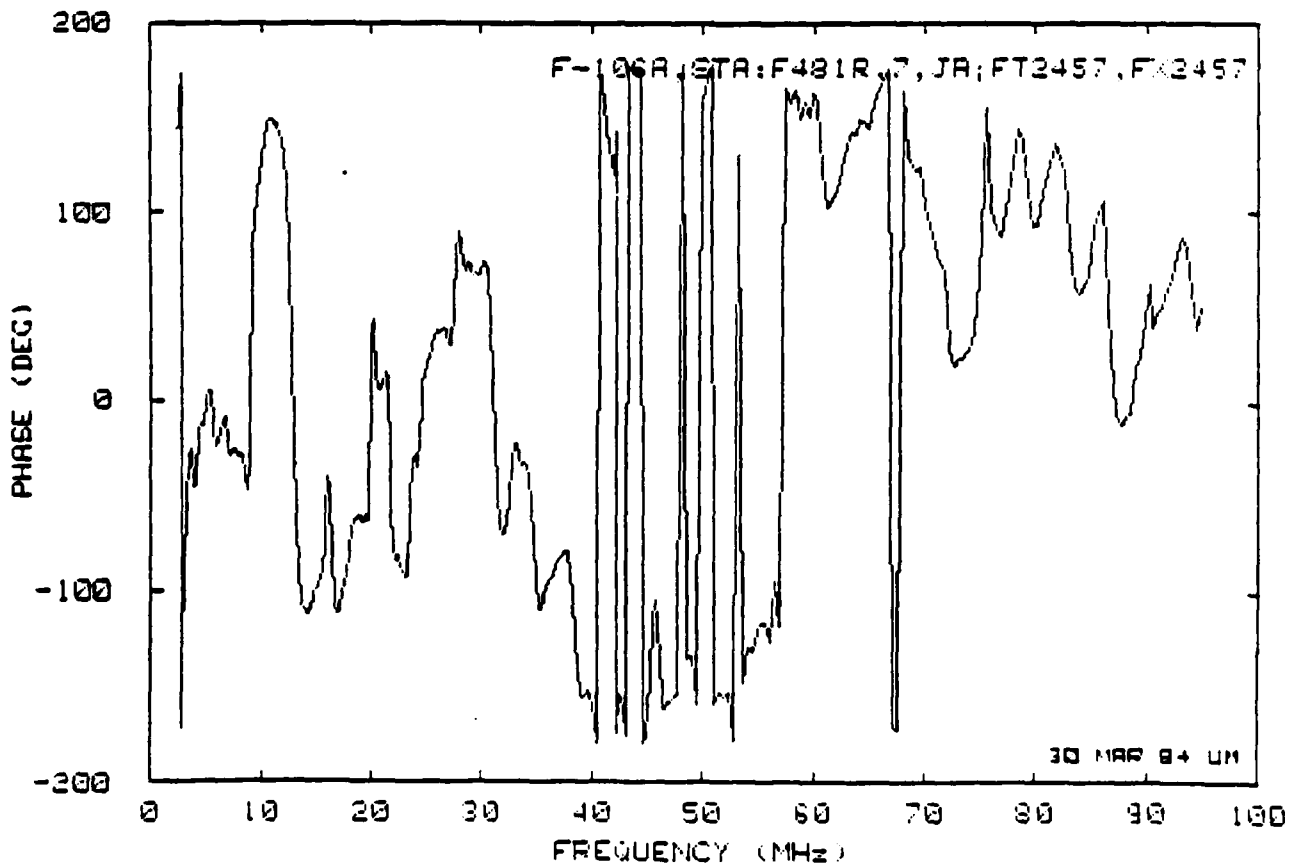
100
FREQUENCY (MHz)
30 MAR 84 UM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PHASE (DEG)
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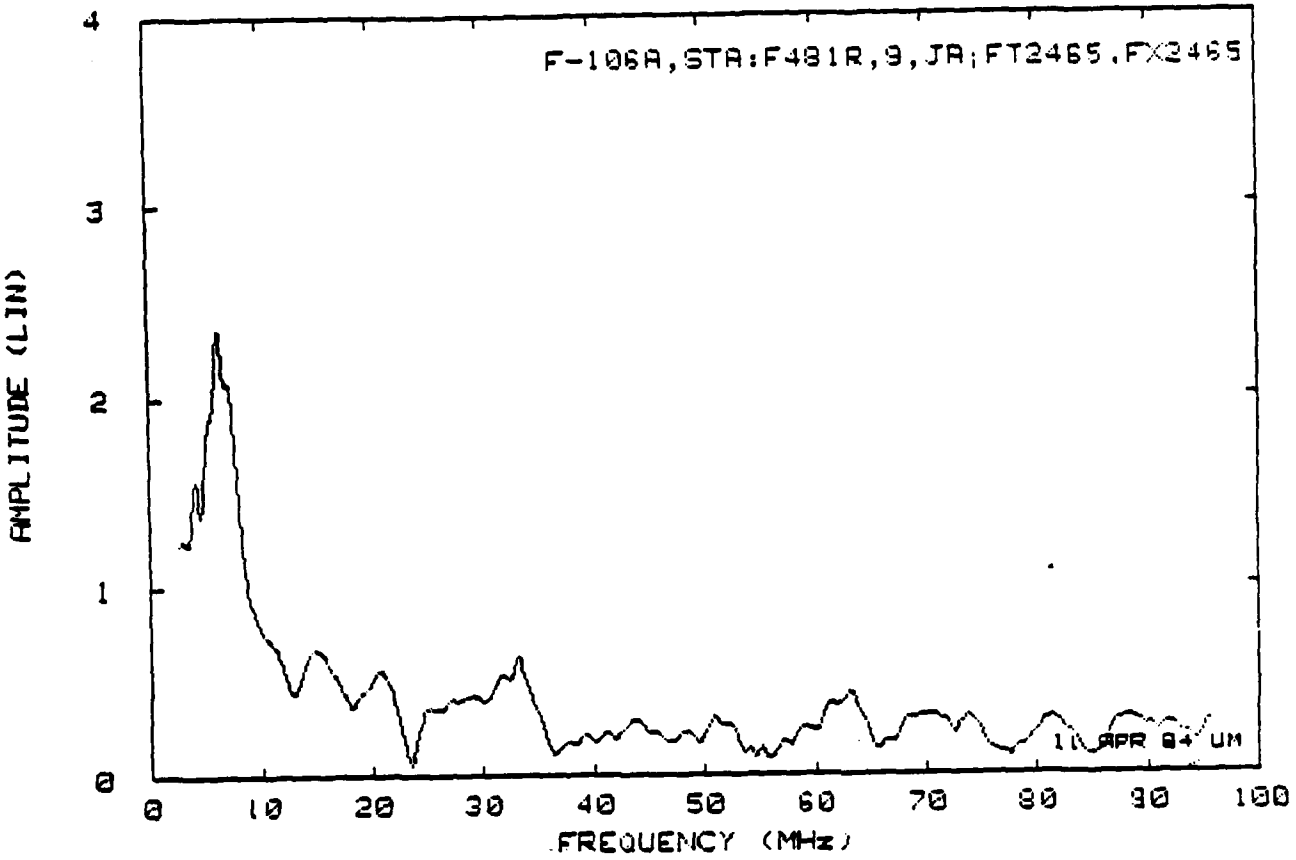
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,9,JR;FT2465,FX2465
AMPLITUDE (LIN)
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60
70
80
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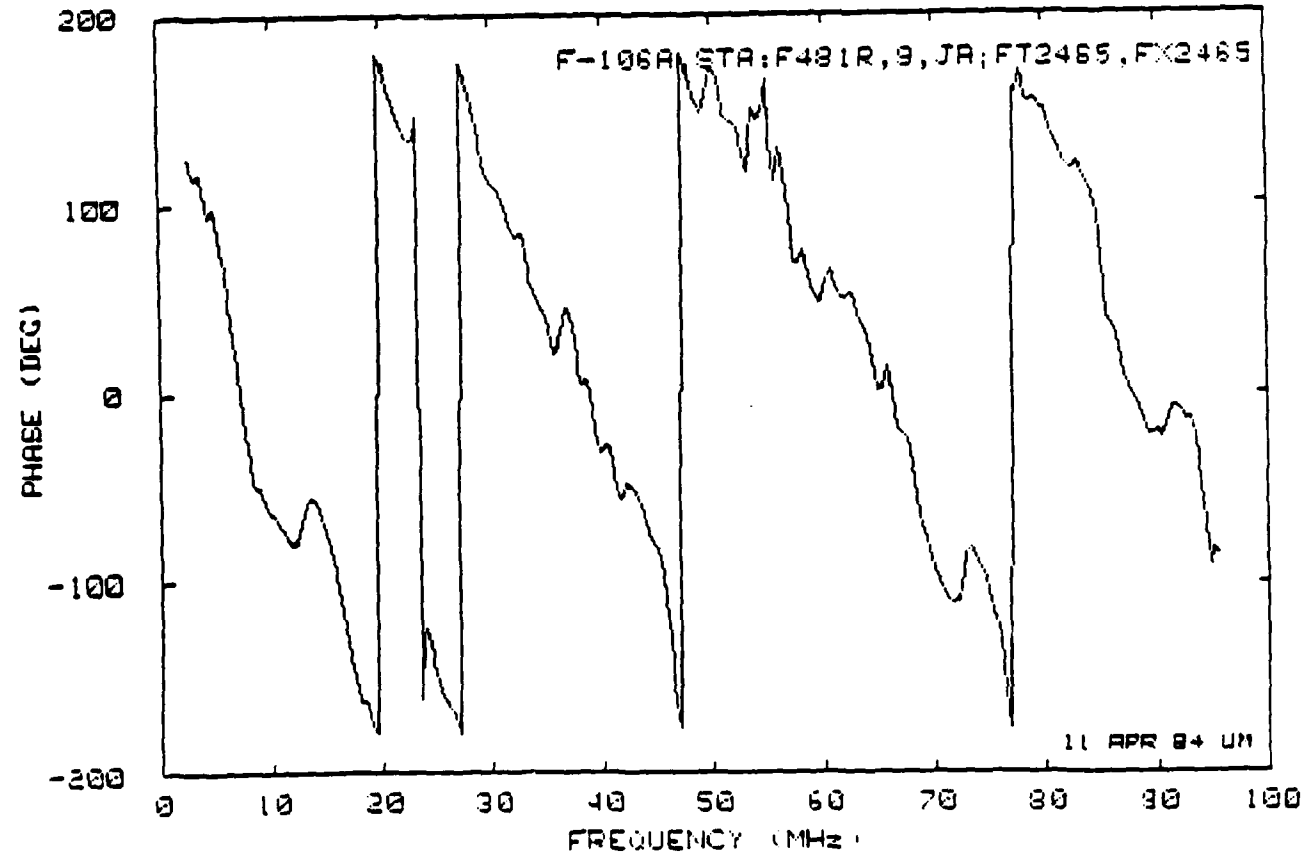
100
FREQUENCY (MHz)
11 APR 84 UM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PHASE (DEG)
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-100
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60
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80
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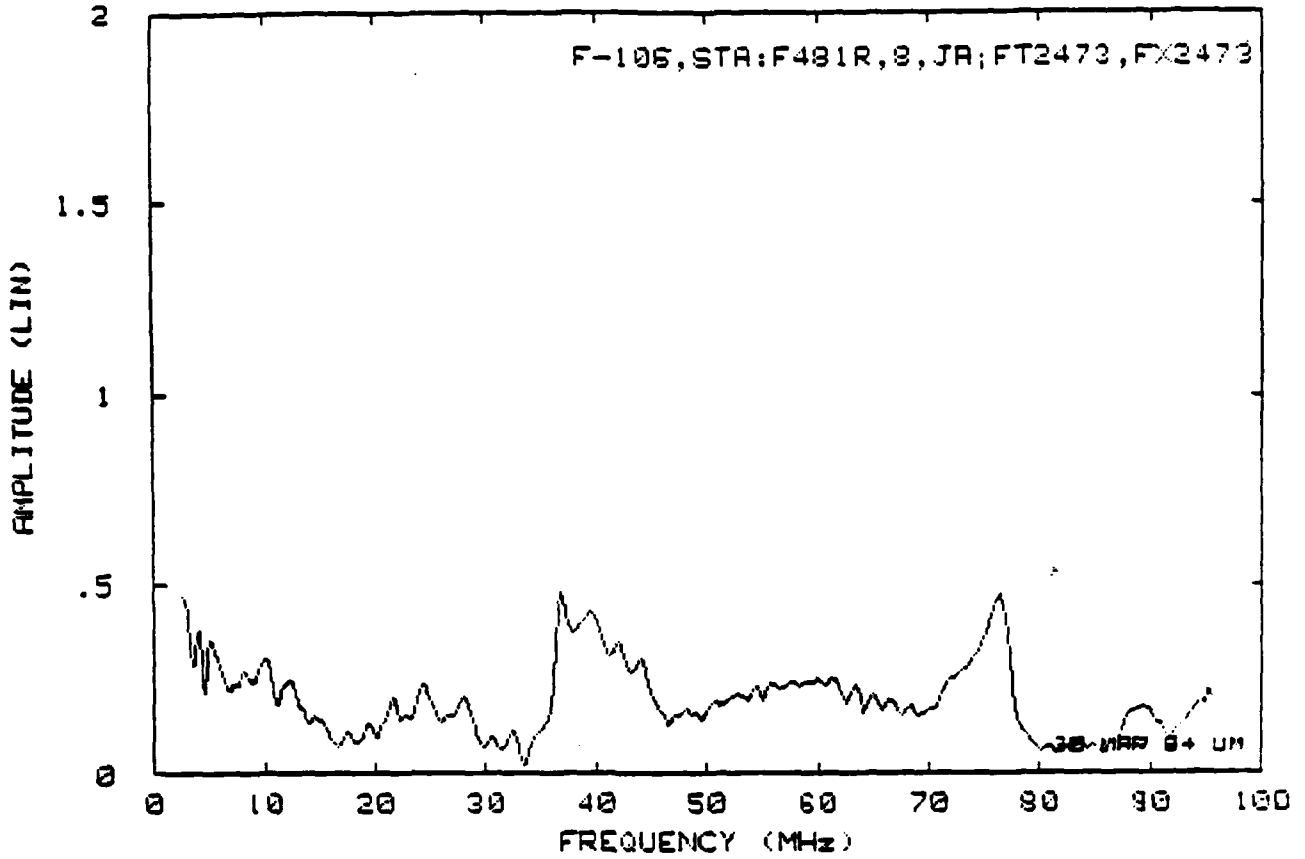
100
FREQUENCY (MHz)
11 APR 84 UM


F-106,STA:F481R,8,JA;FT2473,FX2473
AMPLITUDE (LIN)
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1.5
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.5
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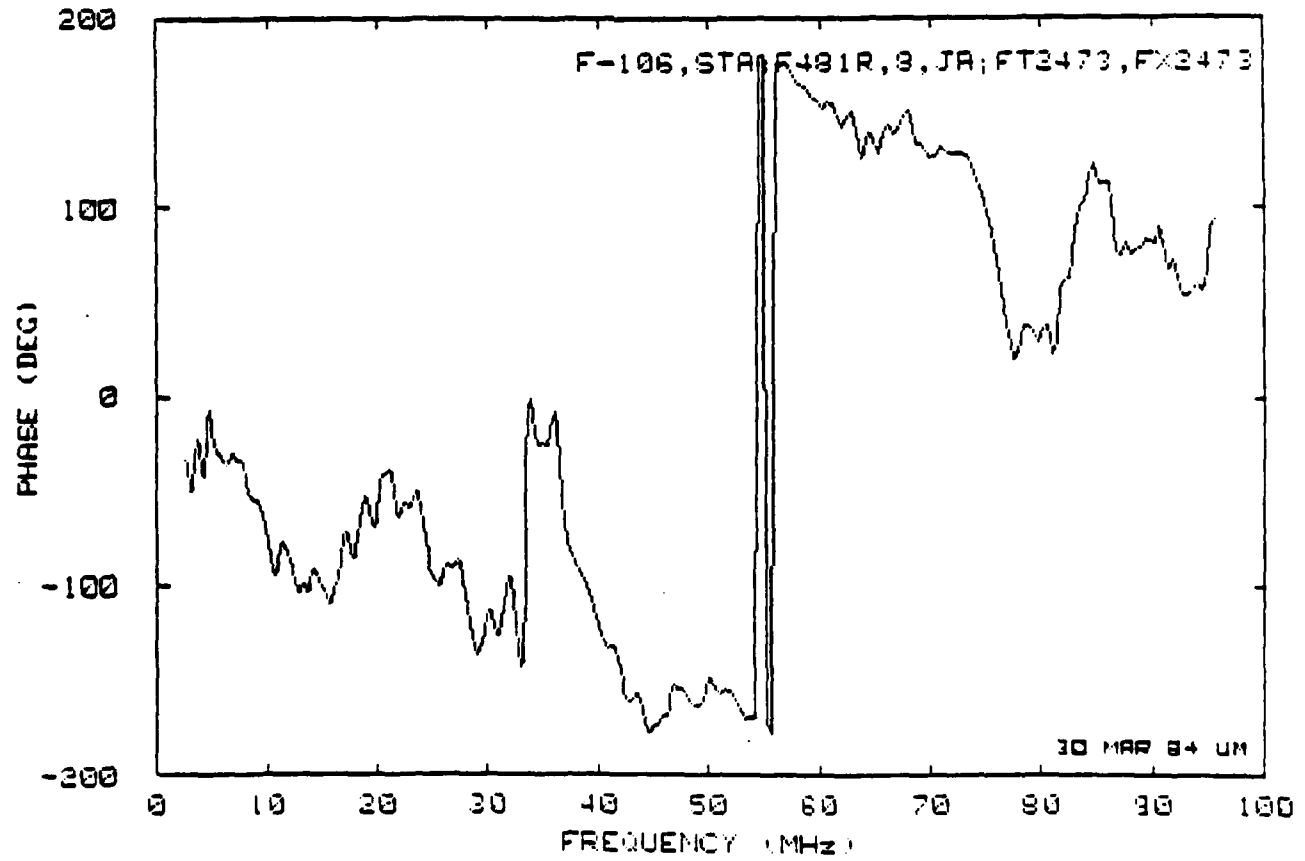
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106,STA:F481R,8,JA;FT2473,FX2473
PHASE (DEG)
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-100
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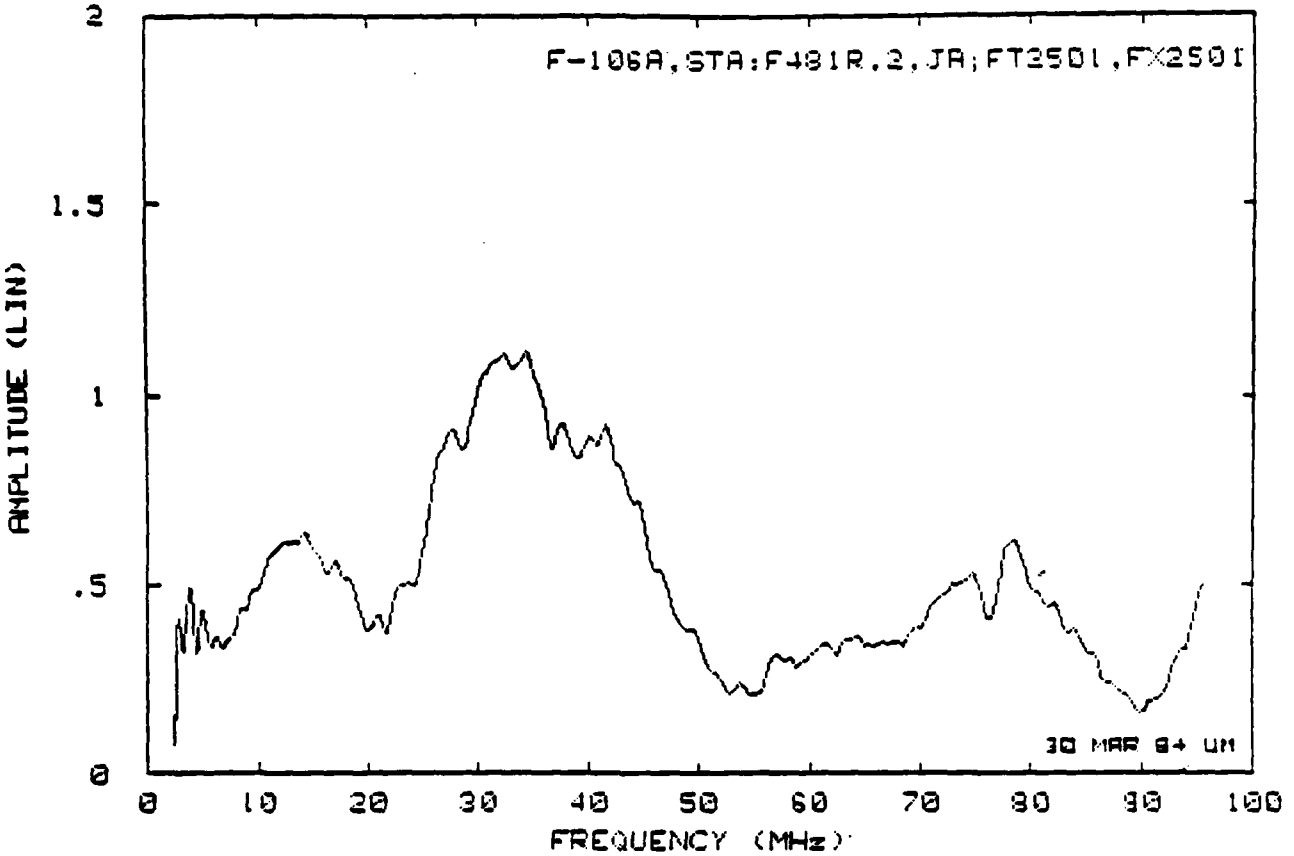
70
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,2,JA;FT2501,FX2501
AMPLITUDE (LIN)
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1.5
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.5
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0
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60
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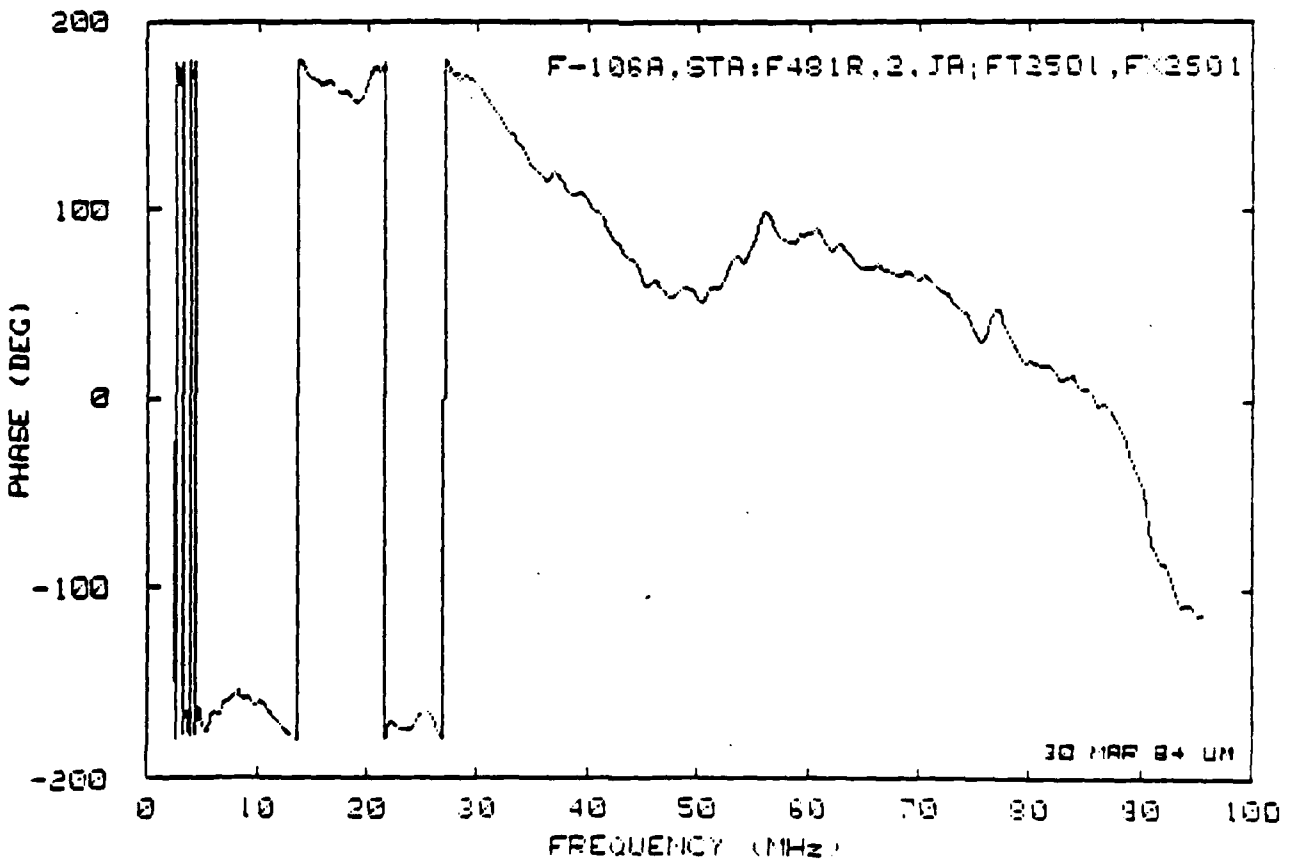
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM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PHASE (DEG)
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-100
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0
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20
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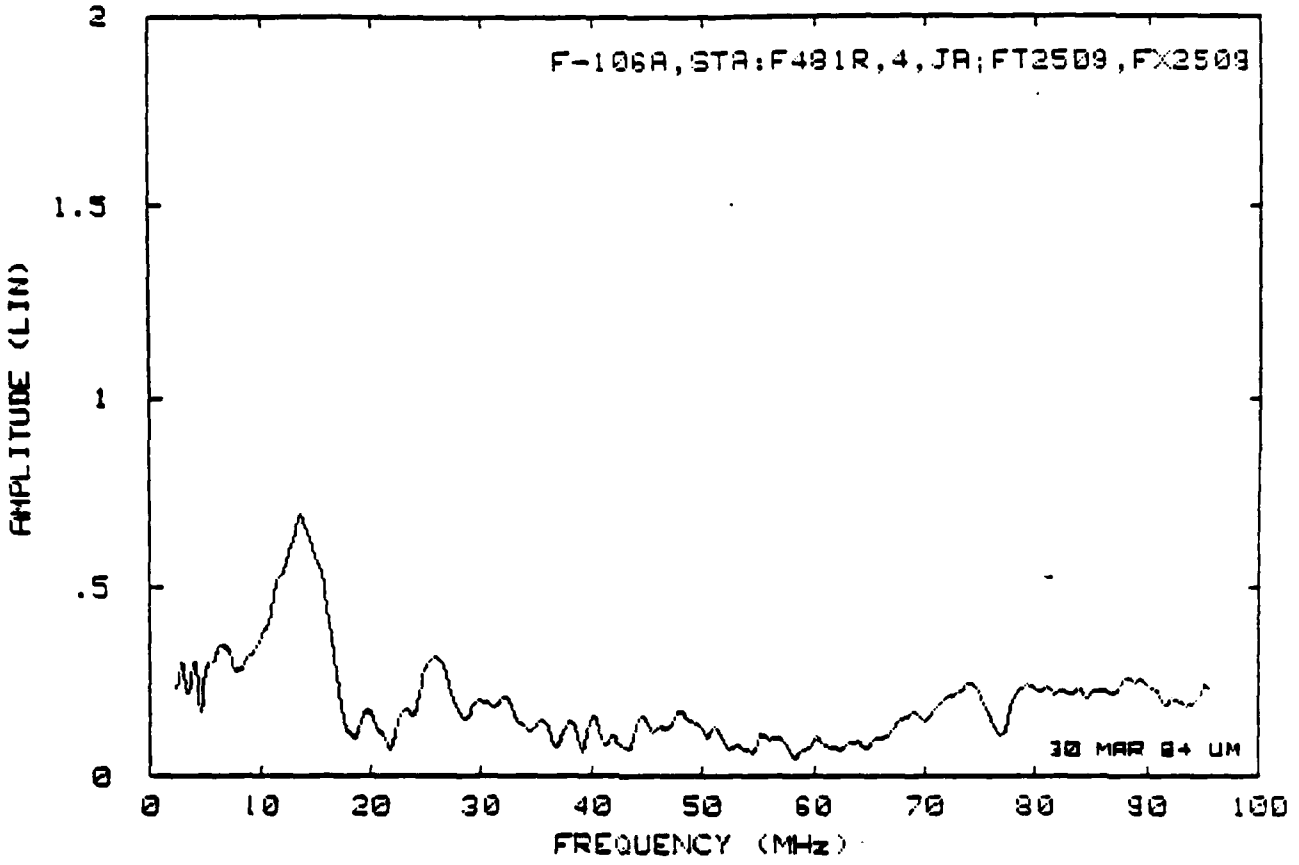
70
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,4,JR;FT2509,FX2509
AMPLITUDE (LIN)
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1.5
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.5
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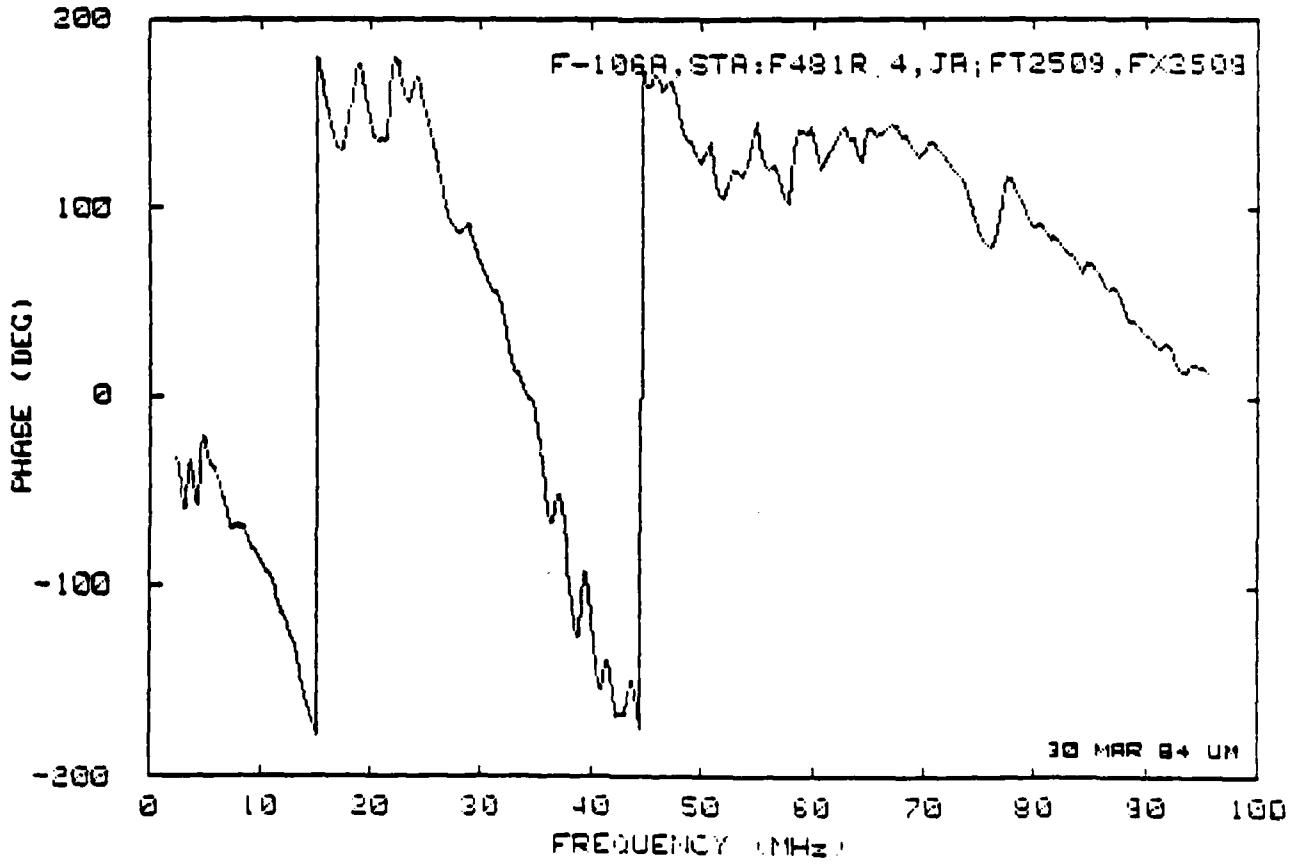
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,4,JR;FT2509,FX2509
PHASE (DEG)
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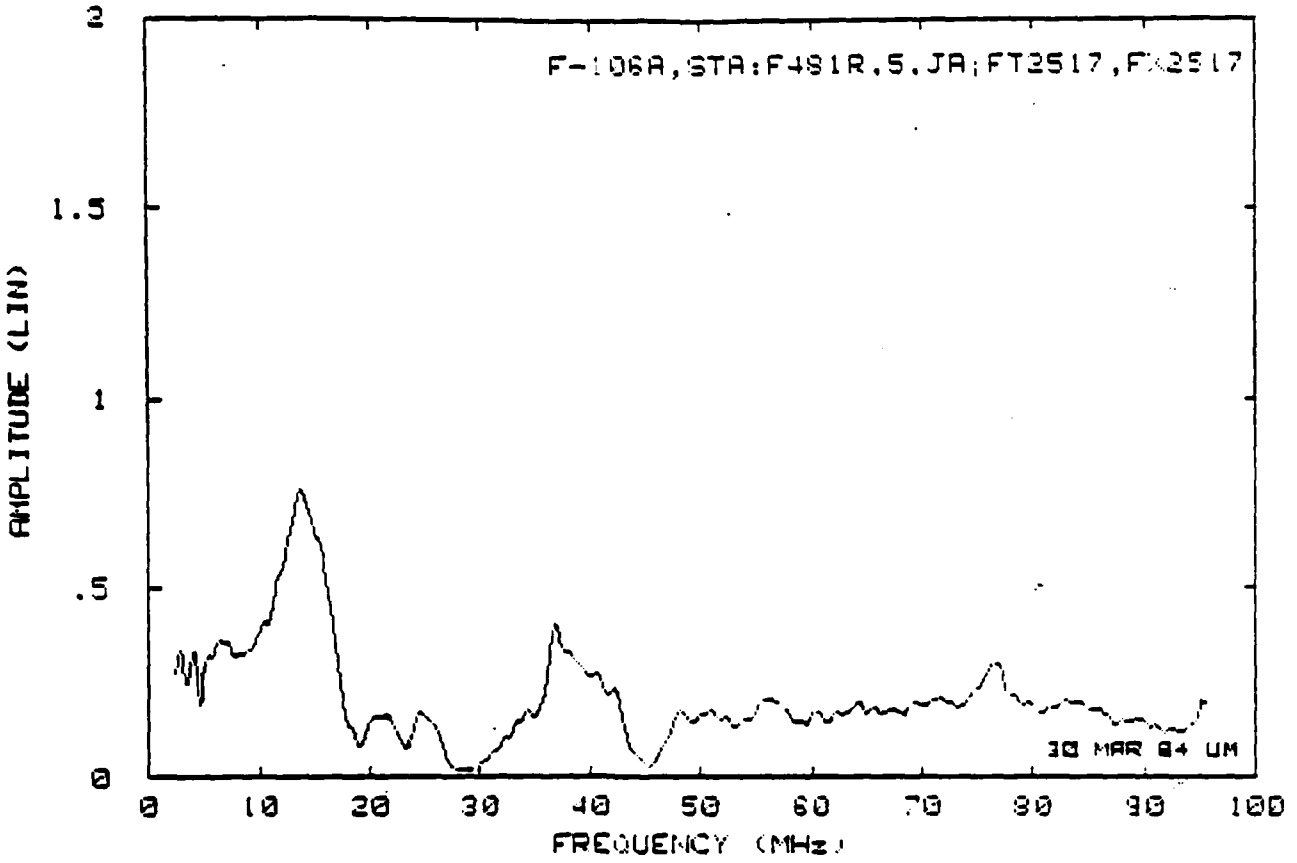
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,S.JA;FT2517,FX2517
AMPLITUDE (LIN)
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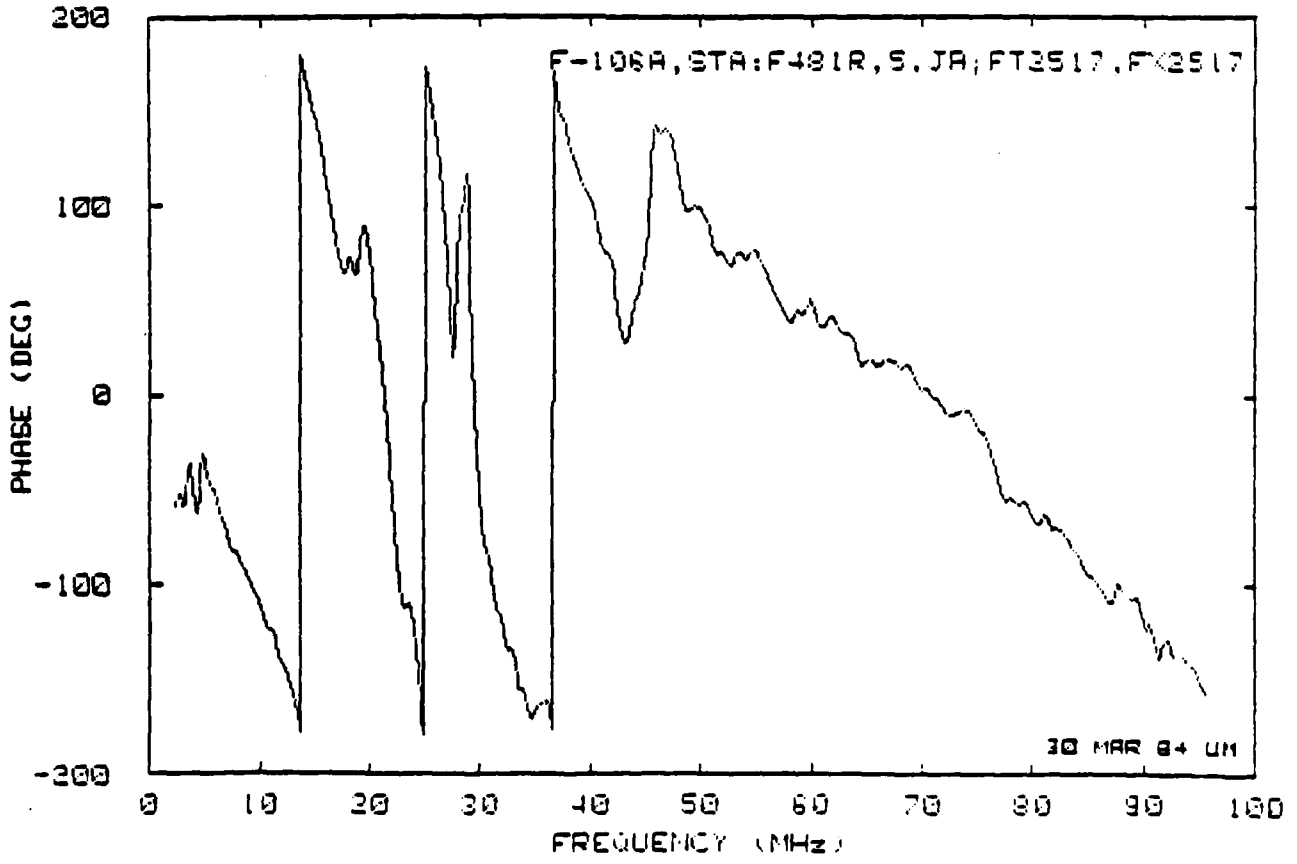
1.5
1
.5
0
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM


F-106A,STA:F481R,S.JA;FT2517,FX2517
PHASE (DEG)
200
100
0
-100
-200
0
10
20
30
40
50
60
70
80
90
100
FREQUENCY (MHz)
30 MAR 84 UM

END

10-86

DTIC